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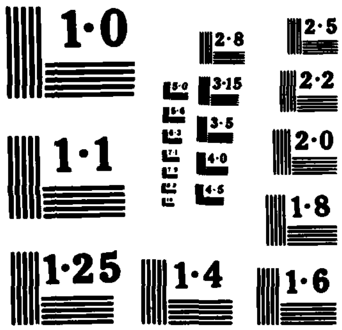
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MOTORS,

JDING EFFECT OF HIGHER HARMONICS

THESIS

E/EE/84S-10

Roy D. McMaster
Capt. USAF

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DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY (ATC)

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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COST EFFECTIVENESS OF "NOLA" CONTROLLED MOTORS, INCLUDING EFFECT OF HIGHER HARMONICS

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science

by

Roy D. McMaster

Capt. USAF

Graduate Electrical Engineer

A-1

December 1980

Preface

The Air Force has a need to conserve energy and to correct the power factor on electric motors. This need brought about a thesis topic. It was proposed that a graduate student do an economic analysis of the "NOLA" Power Factor Motor Controller and the effects the controller may have on the power circuits. A computerized motor and controller simulation would be used to produce the economic analysis and effects on the power circuit.

I chose this thesis topic because I have an undergraduate background in power systems and a desire to better understand these systems. In this thesis I develop a digital-analog simulation model for the motor and controller and implement them on the computer. The data from the simulation is used to make the economic analysis and to determine the effects on the power system.

I would like to thank Dr. Frederick Brockhurst for his guidance throughout all stages of the thesis effort. I would also like to thank my wife for transcribing the rough draft and for her tolerance of me during the preparation of this thesis.

Roy D. McMaster

Abstract

An economic analysis of the "NOLA" Power Factor Motor Controller is accomplished and the effects of the harmonics produced by the controller are studied. The controller is placed in series with each leg of various sizes of wye-connected three-phase motors. The energy saved by the controller, the power factor correction, and the reflected harmonics under varying load conditions are studied to determine the economic advantages. Also the data from the controlled motor is compared to an energy efficient motor.

An analog-digital computer program is developed which models an induction motor and the "NOLA" controller. The computer model is used to determine and analyze the reflected wave shape produced by the controller.

The results of the study indicates that the energy efficient motor is the most cost effective alternative at the present time because of the high initial cost of the "NOLA" controller. Continued studies are recommended to determine the effects of the higher harmonics.

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I. Introduction

Background

In the last few years the public and industrial interest has turned to conserving energy due to the increase in cost of a barrel of oil from about four dollars in the early 1970's to over thirty dollars in 1980. This increase in energy cost led to the invention and development of a power factor motor controller by Frank Nola, an aerospace engineer working at the National Aeronautics and Space Administration's Marshall Space Flight Center in Huntsville, Alabama.

"By interrupting the voltage applied to the motor during portions (Alpha electrical degrees) of each half cycle, the NOLA controller attempts to achieve an essentially constant power factor operation. This results in lower core and winding losses, improving the efficiency of the Machine." The power factor controller (PFC) has been tested on over 50 motors at the Marshall Space Flight Center and has shown energy savings ranging from 0 to 10 percent at rated load and up to 75 percent at no load (Ref. 1: 197). Typical percentage savings versus load for two 3-phase motors and a single phase motor are shown in figure 1 (Ref. 1: 197). Other hardware test results are illustrated in Reference 1; therefore, the purpose of this thesis was not to test the validity of the controller, but, rather, to conduct an economic analysis of the cost of using the controller with conventional induction motors versus the cost of using high

efficiency induction motors.

To conduct the economic analysis, it was necessary to have some way of obtaining real and reactive power consumption by the motor for a variety of load conditions, both with and without the NOLA controller. Therefore a computer model of the PFC and motor was developed and used to generate the data required to determine the economic advantages of using the PFC and it's effects on the power system.

A secondary objective was to investigate the nature of the harmonics impressed on the power system by the PFC.

Approach

The induction motor was modelled by an equivalent circuit and the mesh equations for the circuit were derived. The equations were put into a form suitable for solution on an analog computer and the analog computer was then simulated on a digital computer. This technique is here-after referred to as the analog-digital simulation. The motor was then coupled to the model for the PFC. Power requirements were obtained for a variety of operating conditions both with and without the controller for both conventional and energy efficient motors. These results were then used to conduct an economic analysis of each of the different possibilities.

Assumptions

The primary assumption underlying this approach is that

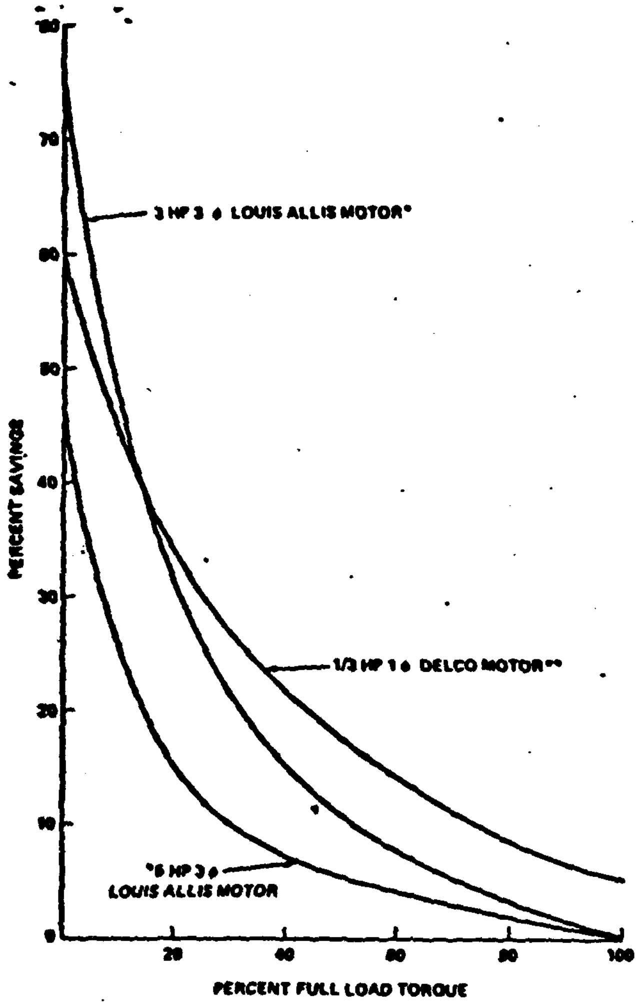
the computer simulation of PFC and induction motor provides reasonably accurate estimates of the real and reactive power requirements of the machine. Clearly the cost comparisons are only as valid as the data used to generate them. Fortunately, machine modeling techniques are well established and have been validated over the years. In addition, results obtained from the model compared closely to manufacturers' test results. The parameters used in the models were obtained from manufacturers' data. Additional assumptions regarding costs (motors, electricity, and controller) as well as period of operation were required to conduct the economic analysis. These are described in detail in Chapter V.

Sequence of Presentation

Chapter II describes the theory of operation of the PFC and how it was modelled in the computer program. Chapter III describes the equivalent circuit of the induction machine and presents a derivation of the equations required for the analog computer simulation of the machine. Chapter IV describes the over-all analog-digital simulation of the PFC and induction motor. Chapter V gives the assumptions and methods used to conduct the economic analysis. The final chapter contains conclusions and recommendations.

There are seven appendices. Appendix A contains the digital program to determine equivalent circuit parameter values and Alpha values for controlled states. Appendix B contains the tables listing the input/output data for motor

elements and Alpha values. Appendix C is the FORTRAN listing of the analog-digital simulation of the PFC and motor. Appendix D contains figures showing the reflected waves of the controlled motors. Appendix E presents a sampling of harmonic data from a Fast Fourier Transform. Appendix F contains the calculations and tables used in the economic analysis. Finally, Appendix G contains tables showing comparisons of actual motor data and the simulated data.



* DATA OBTAINED FROM AUBURN UNIVERSITY REPORT
** NASA/MARSHALL SPACE FLIGHT CENTER (MSFC) DATA

PFC percent savings versus torque for various motors.

Figure 1

II Computer Simulation of the "NOLA" Power Factor Controller

The "NOLA" Power Factor Controller, here after referred to as the PFC, is placed in series with each phase of a wye-connected three phase induction motor. The PFC corrects the power factor and reduces the power losses within the motor when the motor is operated at less than full load. Although the PFC is an electronic control system, it is modelled as an opened or closed switch (TRIAC) in Subroutine V3CONT.

This chapter begins with a brief discussion of the PFC's theory of operation as presented by the inventor. This is followed by how the PFC is modelled for computer simulation.

PFC Theory of Operation

The PFC is an electronic circuit that monitors and controls the terminal voltage and the phase angle, or power factor, of the current applied to the motor.

> The PFC senses the line voltage and current and produces a voltage proportional to the phase angle between the two. This voltage is summed with a reference voltage that is indicative of a desired phase angle. The difference in these two voltages is an error voltage which, after conditioning, controls the turn-on or firing angle of a solid

state switch (TRIAC) that is in series with the motor (see Figure 2). The TRIAC is turned on for a portion of each half cycle as in a typical phase control circuit such as used in a light dimmer switch. This varies the applied voltage to the motor as a function of the load and forces the phase angle between voltage and current to remain constant, within the limits of the motor, at the commanded value regardless of changes in load. Thus, by controlling the magnitude of the motor terminal voltage to only that necessary to over come torques attendent to less than fully loaded conditions, the losses associated with full line voltage are minimized (Ref 1:194).

Computer Simulation of PFC

As mentioned in the opening paragraph of this chapter, the PFC is modelled as an opened or closed switch which is switched open when the current approaches zero. The switch will stay open for a preset period of time which is called Alpha. Typical results of the switching action on the current and voltage are shown in Figure 3.

The logic of the 3-phase voltage controller, subroutine V3CONT, determines the correct position of the switch of each phase independently and is the same for each phase. Therefore, only one phase of the three-phase controller will be explained. A "Mini" flow chart for subroutine V3CONT is shown in Figure 4.

The logic for phase one is as follows: Check the position of the switch. If the switch is closed then see if the preset point counter value has been exceeded. If the point counter value has not been exceeded, then the controller will skip all other tests on phase one and will not change the position of the switch. The point counter test allows the current time to leave zero value once the switch is closed. If the preset counter value is exceeded then the magnitude of the current is sampled. If the current is less than one tenth of an ampere then the current is approaching a zero crossing and the switch will be opened for the preset time of Alpha. When the switch is opened the voltage and current are set to equal zero and the point counter is reset. The switch is closed then the above tests are repeated until another current zero crossing is sensed.

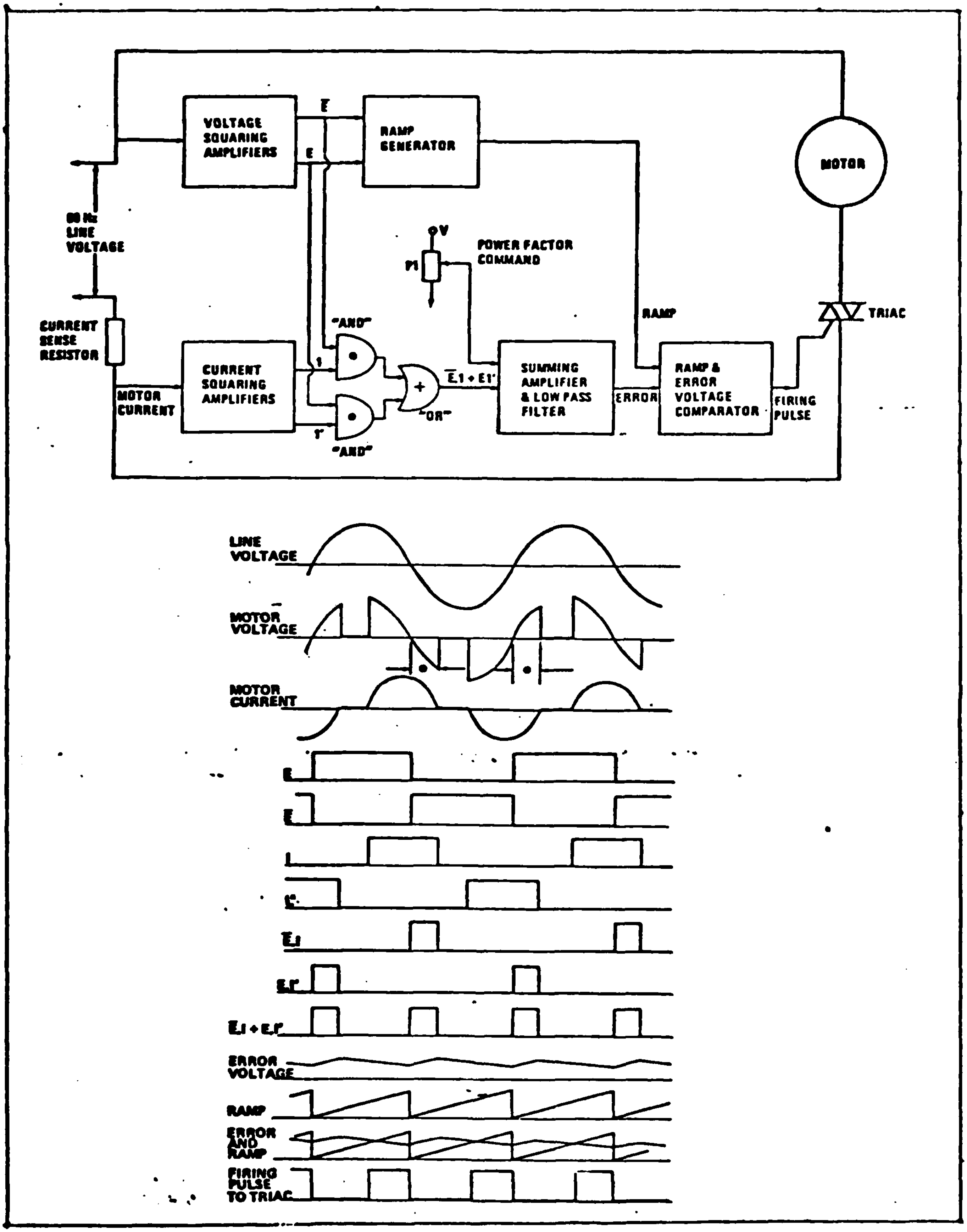


Figure 2 PFC Block, Diagonal and Wave Forms

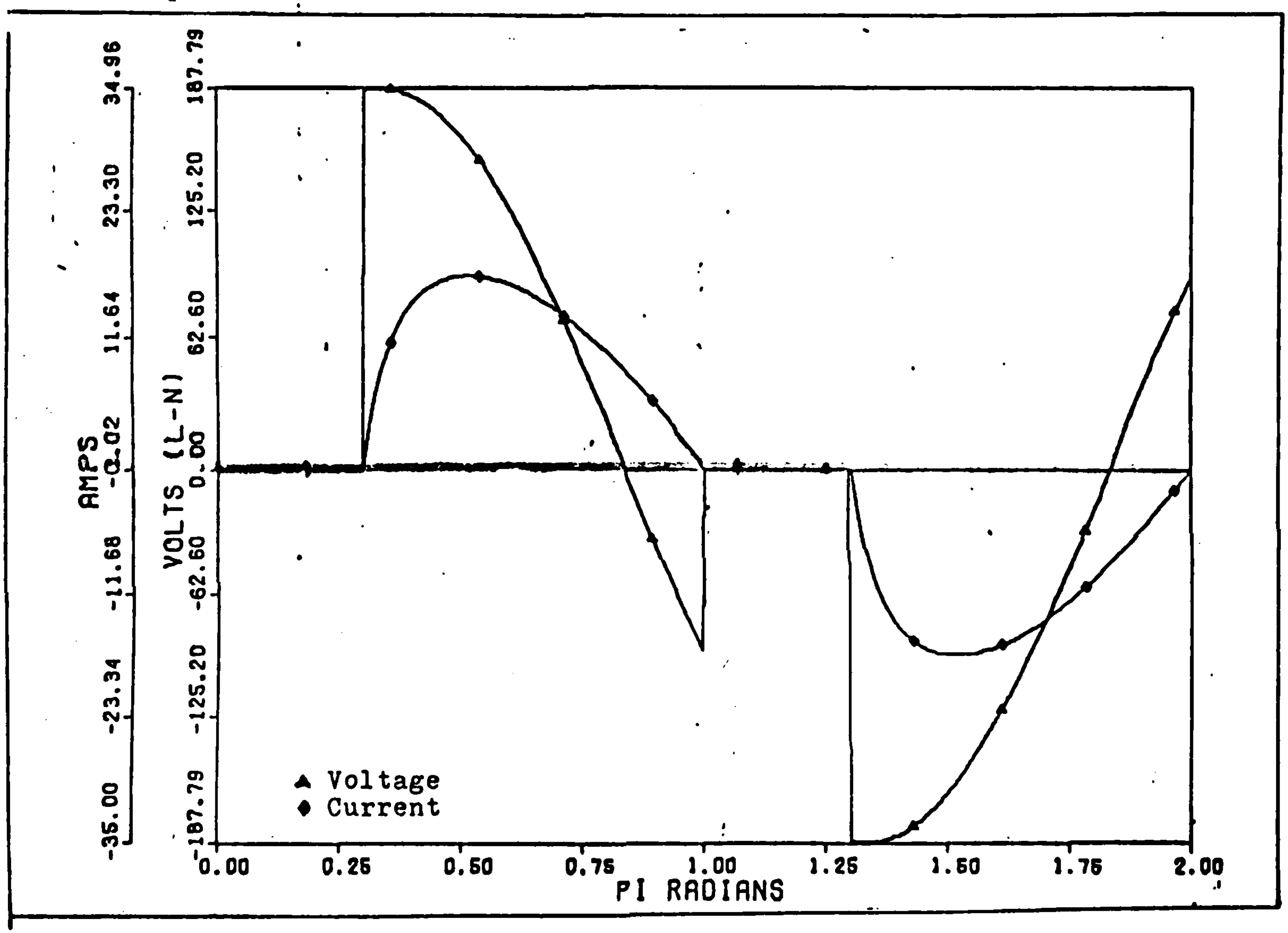


Figure 3

Reflected Voltage and Current Wave for

5 Horse Power Energy Efficient with ALPHA equal 0.95

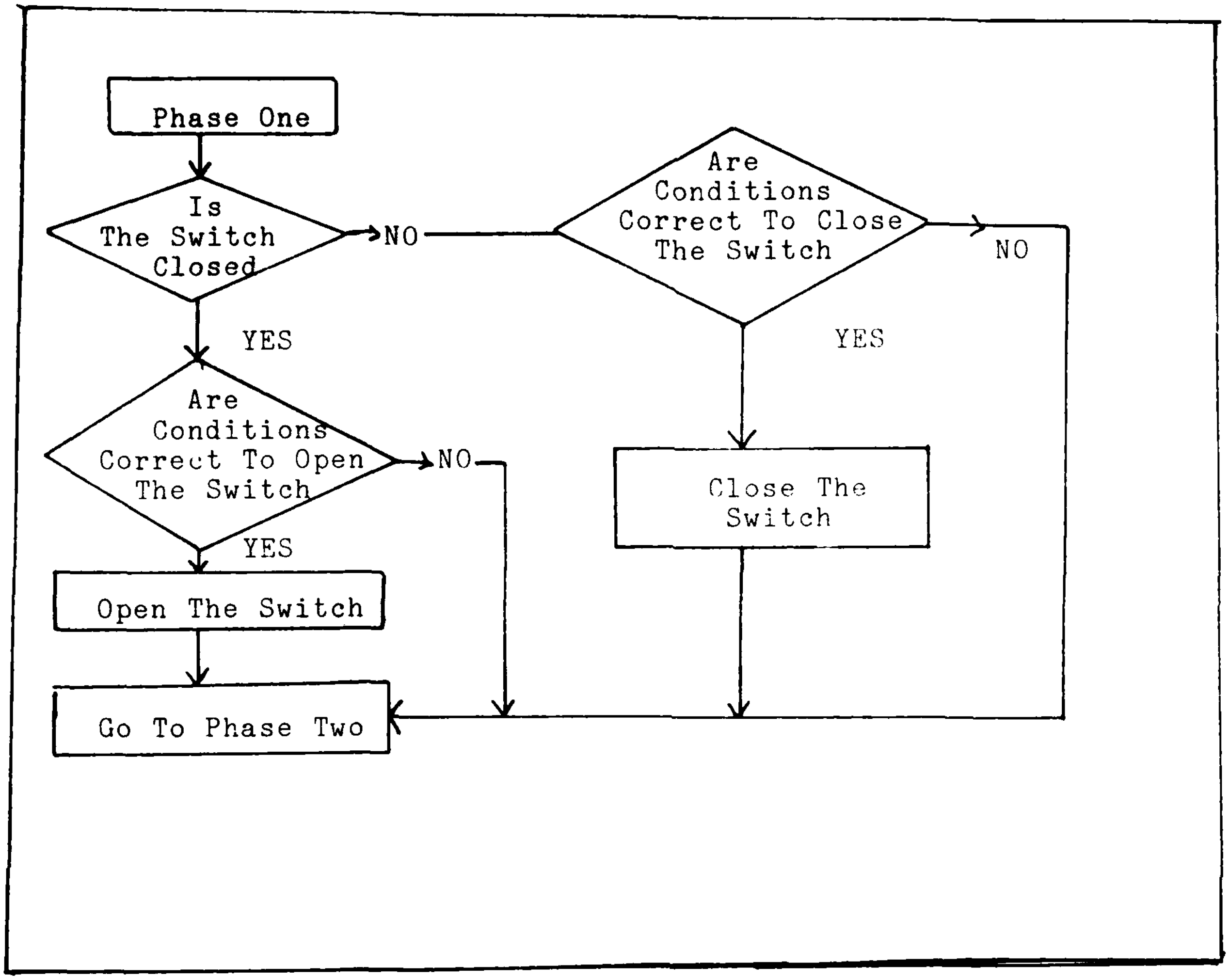


Figure 4 "Mini" Flow Chart For Subroutine V3CONT

III Mesh Analysis of a Wye-Connected Induction Motor

A mesh analysis of the per-phase equivalent circuit of a wye-connected induction motor is used to determine the currents within each portion of the motor.

Per-Phase Equivalent Circuit

The per-phase equivalent circuit is shown in Figure 5 (Ref.: 3) and represents the three major components of the motor which are typical of both energy efficient and standard motors. First, the stator is represented by elements R1 and L1, where R1 is the stator resistance and L1 is the stator inductance. The input current I1 is the total circulating current in the stator. Next, L2 and R2 represent the magnetizing inductance and core loss resistance in the core. The current I2 circulates in the core. The elements L3 and R3 represent the inductance and resistance in the rotor.

$$P_o = I3^2(R3(1-S)/S) \qquad (1)$$

If the values of elements of the equivalent circuit and the voltage applied are known, then the power output and losses of the motor may be calculated using mesh equations.

Derivation of the Mesh Equations

The mesh equations are derived by writing loop equations around each loop of the equivalent circuit (Figure 5).

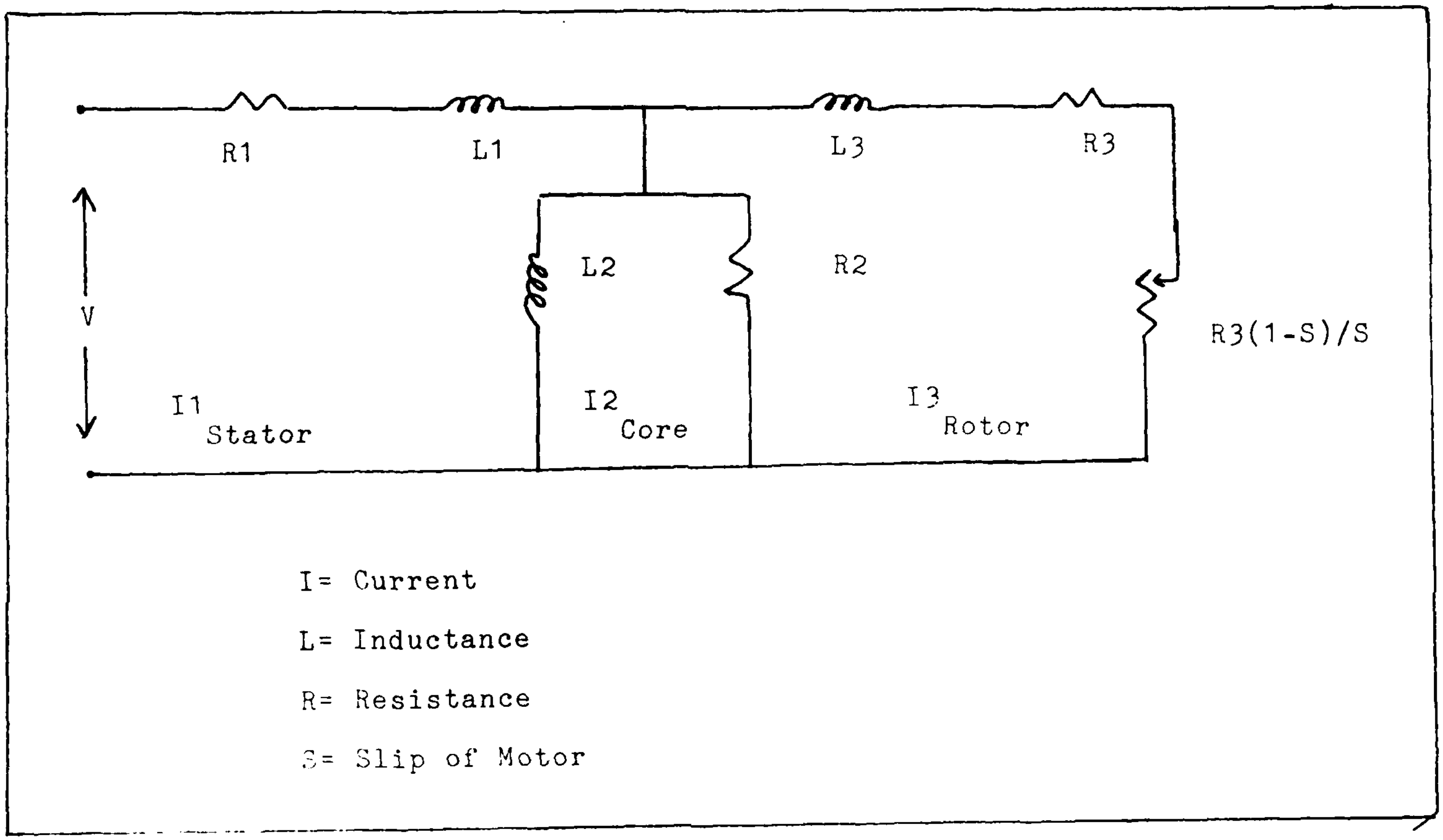


Figure 5 Per-Phase Equivalent Circuit

Then, combine the loop equations to solve for the current derivatives.

Figure 6 contains the current symbols used in the loop equations and the computer simulation.

$$Y1 = I1, \quad Y2 = I2, \quad Y3 = I3$$

$$X1 = \frac{DI1}{dt}, \; X2 = \frac{dI2}{dt}, \; X3 = \frac{dI3}{dt}$$

$$V = \text{Input Voltage}$$

Figure 6. Loop Equation Symbols

The Loop equations are as follows:

$$V = R1Y1 + L1X1 + L2X1 - L2X2 \tag{2}$$

$$O = -L2X1 + L2X2 + R2y2 - R2X3 \tag{3}$$

$$O = -R2Y2 + L3X3 + R3Y3 + R2Y3 + R4Y3 \tag{4}$$

The equations are combined to solve for the derivatives X1, X2, and X3.

$$X1 = (-R1Y1 + R2Y2 - R2Y3 +V) /l1 \tag{5}$$

$$X2 = (L2R1Y1 / (L1 + L2) - L2V/(L1 + L2) + R2(Y2 - Y3)) / ((L22/(L1+L2)) -L2) \tag{6}$$

$$X3 = (R2Y2 - (R3 + R2 + R4) Y3) / L3 \tag{7}$$

<u>Analog Configuration</u>

An analog integration of equations (5), (6), and (7) is

used to obtain point by point data for the steady state solution.

Figures 7 and 8 represent the analog configuration of the per-phase equivalent circuit as used in the analog-digital simulation. The program for this is contained in Appendix C.

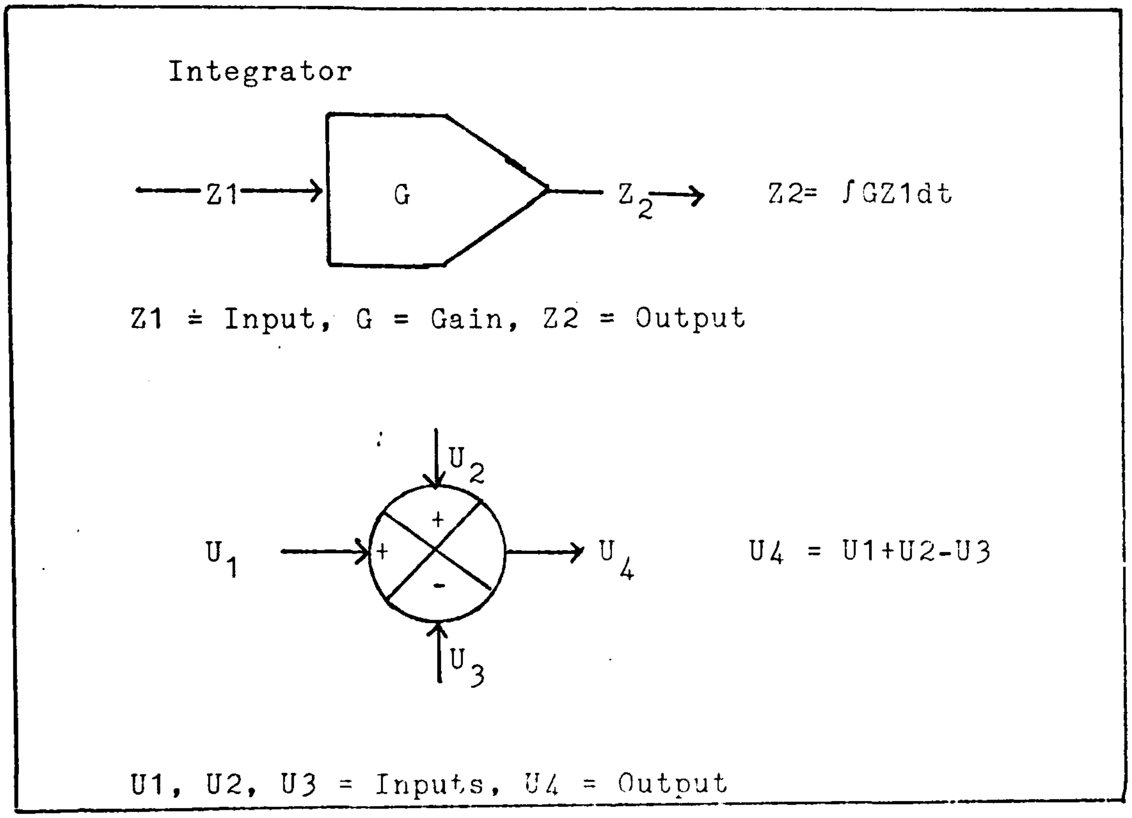


Figure 7 Analog Integrating and Summing Elements

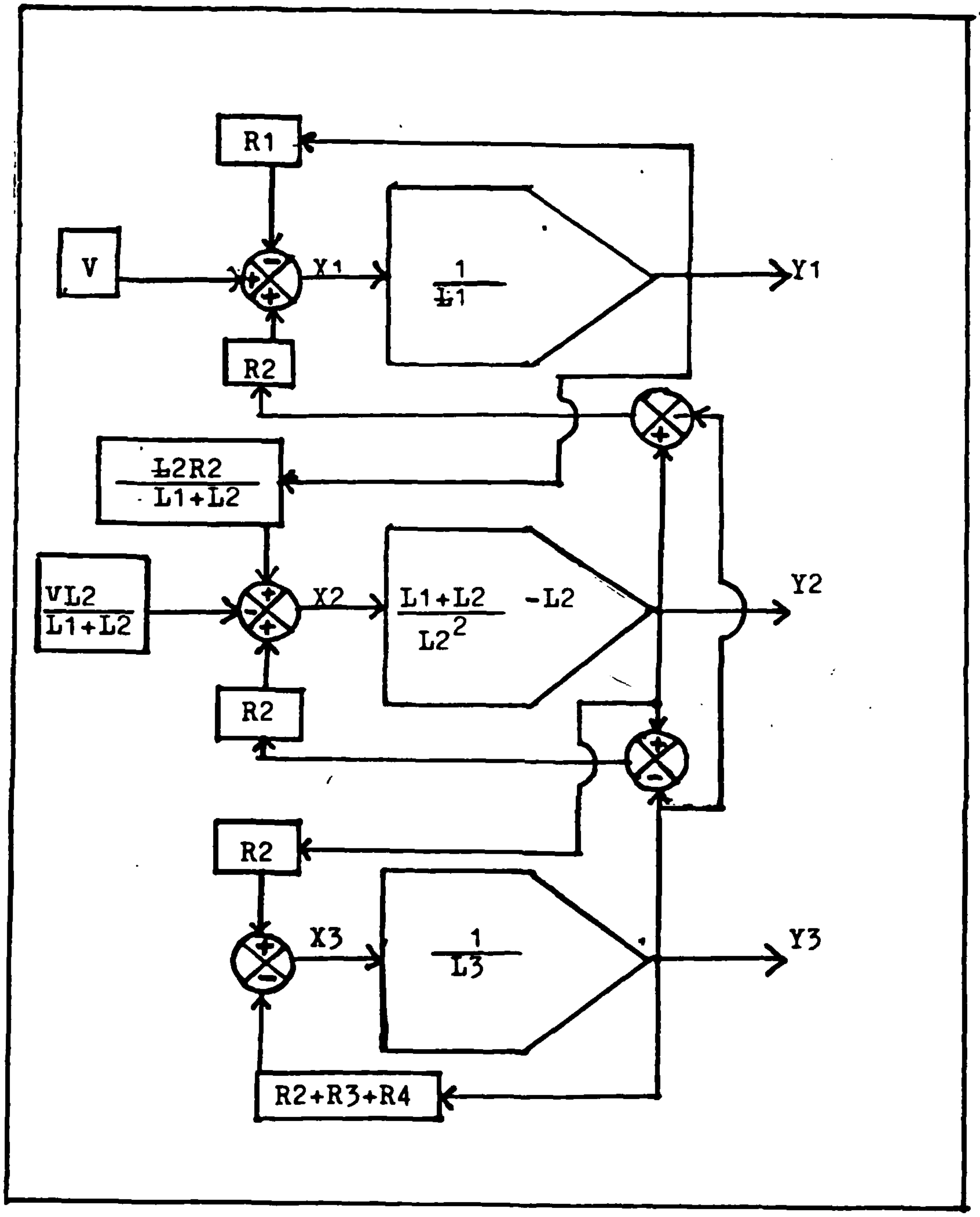


Figure 8 Per-Phase Analog Configuration for A Wye-Connected Induction Motor

IV. Analog-Digital Simulation of the Induction Motor and Controller

This chapter gives a brief description of the procedures and computer programs used to produce the data generated for the cost analysis and for the harmonic reflected wave shapes. Figure 9 is a mini flow chart showing the steps taken to generate the required data.

Computation of Equivalent Circuit Values

The equivalent circuit values were computed using the program listed in Appendix A. Manufacturer's no load and full load test data (Appendix G) were used to generate the values for the parameters of the motor equivalent circuit shown in Chapter III.

The program and data were furnished by Dr. Frederick Brockhurst (Ref. 2).

Alpha Angles

The same program and reference data which were used to compute the equivalent circuit values were also used to compute the power factor and Alpha angle to be used in the motor controller simulation.

The Alpha angle was computed in subroutine CONT which uses an estimating parameter technique. The input/output data is shown in Appendix B.

Analog-Digital Integration

A program was written to simulate the combined operation

of the PFC and induction motor. The program (listed in Appendix C) is capable of calculating the motor losses for a variety of load conditions. This program was used to generate the data required to plot the reflected voltage and current wave shapes listed in Appendix D. The data may also be used to determine harmonic content of the reflective wave

The performance of the machine simulation was verified by comparing calculated values of current, power, speed, efficiency, and power factor to manufacturers' data. These results are shown in Appendix G and agreed quite closely.

Computation of Harmonic Content of the Reflected Current

The harmonic content of the reflected current was calculated by using a Fast Fourier Transform program as listed in Appendix C.

A sampling of the results of the Fourier Transform data is shown in Appendix E.

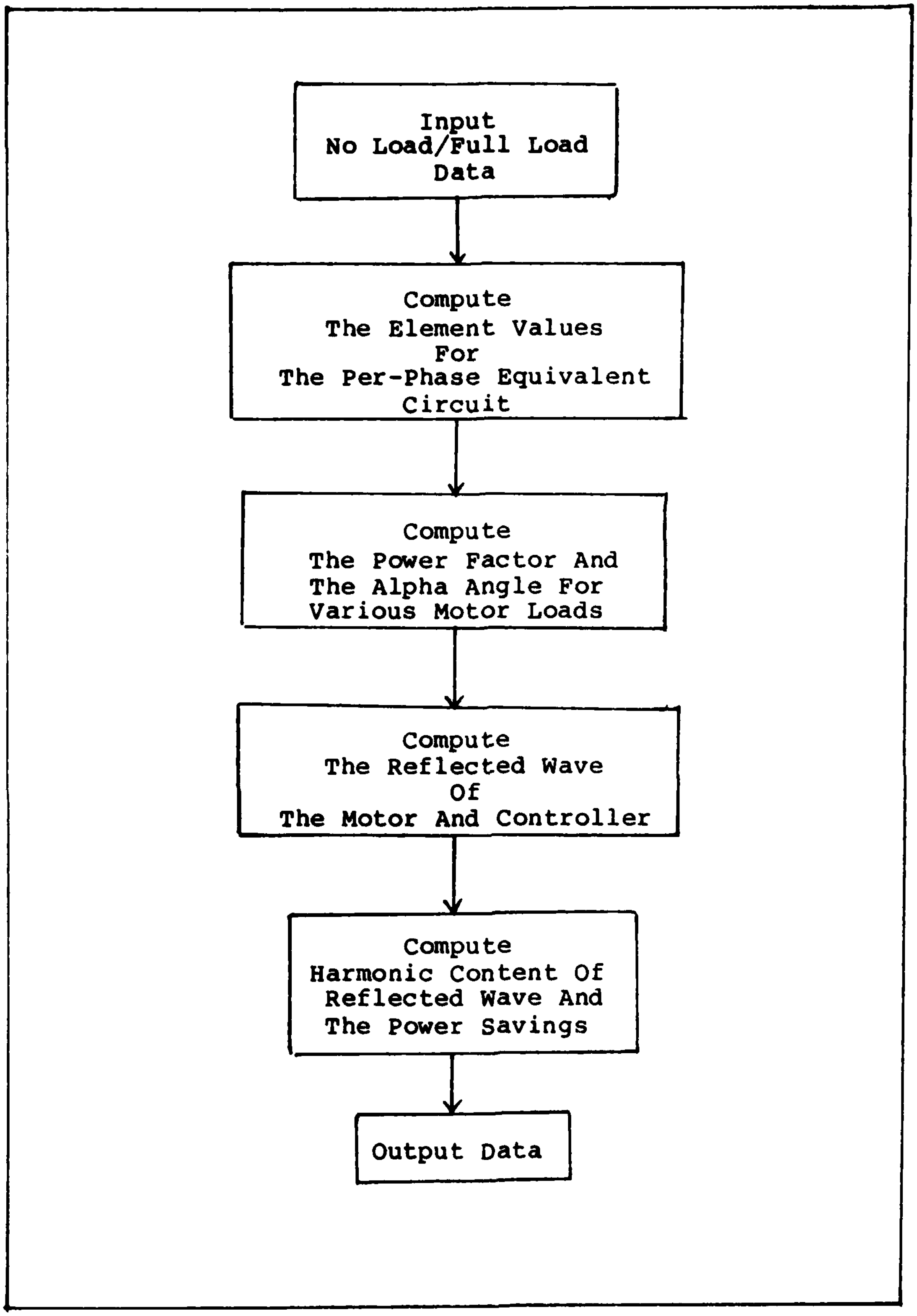


Figure 9 Mini Flow Chart of Computer Simulation

V. Cost Analysis of Controller and Motor

This chapter introduces 6 possible cases for motor/controller configurations. The assumptions that apply to the analysis and the method by which the analysis was prepared.

The cost analysis is separated into 6 possible cases for the 5 horsepower and the 10 horsepower motors. Each case uses a simple payback method based on a fixed number of running hours per year, the calculated power savings and the estimated cost of the motor and controller.

Equation 8 shows the method used to calculate the estimated cost savings per year.

$$\text{\$saved/year} = \text{hours/year} \times \text{estimated watts saved} \times \text{\$cost/kilowatt hour} \times \text{kilowatt/1000 watts} \tag{8}$$

The following assumptions were used in the above equation.

1. 8760 hours per year was used to show continuous operation. If a motor does not operate continuously or operates at various loading then the motor data shown in tables A and B may be prorated to estimate the annual savings.

2. $0.06 per kilowatt hour was used as an average cost for power. This cost can be adjusted to fit the estimated

energy cost in a particular area of the country.

3. A standard 5 horse power motor costs $329.00.

4. An energy efficient 5 horse power motor costs $370.00.

5. A controller for a 5 horse power motor costs $550.00.

6. A standard 10 horse power motor costs $505.00.

7. An energy efficient 10 horse power motor costs $655.00.

8. A controller for a 10 horse power motor costs $850.00.
Assumptions 3 through 8 were based on local vendor prices (1980).

The simple payback method is used to show the estimated payback in years. Once the exact cost of a system and power is known for a given location and time then a life cycle cost analysis may be used. The formula for the simple payback method used is

$$\text{yrs to payback} = \text{system cost/ cost savings/ year} \qquad (9)$$

The following 6 cases were considered:

1. The first case is the comparison of an energy efficient motor without motor controller with a standard motor without motor controller.

2. The second case is the comparison of an energy efficient motor without controller with a standard motor with motor

controller.

3. The third case compares an energy efficient motor with motor controller with a standard motor with motor controller.

4. The fourth case compares an energy efficient motor with motor controller with a standard motor without a motor controller.

5. The fifth case compares a standard controlled motor with a standard uncontrolled motor.

6. The sixth case compares an energy efficient controlled motor with an energy efficient uncontrolled motor.

Each case except #2 and #3 also compare the simple payback in years for a new installation and retrofit for each motor loading.

All of the data and calculations for the six cases using 5 and 10 Hp motors are shown in Appendix F. A portion of the data is shown below to illustrate the method and results.

Table A shows the energy savings (or less) for each of the six cases using 5 Hp motors. For example case 1 shows the savings obtained by using an energy efficient motor (EEM) instead of a standard motor. Similarly case 2 shows the savings obtained by using an EEM instead of a controlled standard motor. Note that for cases 2 the EEM is more efficient down to about half-load, but below half-load the

controlled standard motor is more efficient. This is indicated by the negative signs for the last three entries in column #2. Note that from column 6, there appears to be little benefit from putting a controller on an EEM unless it is very lightly loaded.

Once the differences in wattage for the different cases and loads were known, equation 8 was used to calculate the annual dollar savingS (loss). Table B shows these results for the 5 Hp motor. Again negative signs indicate that the second alternative is more economical.

Finally the payback period was calculated both for new installation and for retrofit installations. Table C shows the payback periods for Case I using 5 Hp motors. For new installations only the difference in cost must be repaid, while for a retrofit installation the entire cost of the motor, controller (if used), and labor must be repaid. Tables D and E show payback periods for the 5 Hp and 10 Hp motors, respectively, for all six cases. Negative numbers in these tables indicate that the option being considered has a higher operating cost. The details of the exact cost used to calculate the payback periods are shown in Appendix F.

5 HP

Δ Wattage for (Situation)

1. Energy Efficient (uncont) VS Standard (uncont)
2. Energy Efficient (uncont) VS Standard (Cont)
3. Energy Efficient (cont) VS Standard (cont)
4. Energy Efficient (Cont) VS Standard (uncont)
5. Standard (cont) VS Standard (uncont)
6. Energy Efficient (cont) VS Energy Efficient (uncont)

Savings in Watts

HP Load	#1	#2	#3	#4	#5	#6
5	64	64	67	67	0	3
4.5	97	151	110	56	-54	-41
4.0	129	108	63	84	21	-45
3.75	64	54	47	57	10	-7
3.0	120	77	46	90	43	-30
2.5	118	20	80	178	98	60
2.0	116	-41	3	161	158	45
1.25	113	-79	18	209	192	97
0.75	113	-130	20	263	243	150

Table A

5 HP Savings/Year Based on $0.06 KWH

HP Load (Situation)	Comparison					
	#1	#2	#3	#4	#5	#6
5	$33.63	$ 33.63	$35.22	$ 35.22	$ 0	$ 1.58
4.5	$50.98	$ 79.36	$57.82	$ 29.43	$-28.38	$-21.55
4.0	$67.80	$ 56.76	$33.11	$ 44.15	$ 11.04	$-23.65
3.75	$33.63	$ 28.38	$24.70	$ 29.96	$ 5.26	$ -3.68
3.0	$63.07	$ 40.47	$24.18	$ 47.30	$ 22.60	$-15.77
2.5	$62.02	$ 10.51	$42.05	$ 93.55	$ 51.50	$ 31.54
2.0	$60.97	$-21.54	$ 1.58	$ 84.62	$ 83.05	$ 23.65
1.25	$59.39	$-41.52	$ 9.46	$109.85	$100.92	$ 50.98
0.75	$59.39	$-68.33	$10.51	$138.23	$127.72	$ 78.84

Table B

#1

5 HP

Simple Payback

Cost/Savings per Year

Standard \$329.00, Energy Efficient 370.00

A= Cost = \$41.00, B= Cost = \$370.00 + 20% = \$444.00

Installation Cost

HP Load	A	B
5	1.22 yrs	13.20 yr
4.5	0.80 yrs	8.71 yr
4.0	0.60 yrs	6.55 yr
3.75	1.22 yrs	13.20 yr
3.0	0.65 yrs	7.04 yr
2.5	0.66 yrs	7.16 yr
2.0	0.67 yrs	7.28 yr
1.25	0.69 yrs	7.48 yr
0.75	0.69 yrs	7.48 yr

B= Retrofit - Replacing Standard Motor with Energy Efficient + 20% Motor Cost Installation

A= New Installation, Cost of Energy Efficient vs Standard Motor based on continuous operation

Table C

5 Horse Power Motor and Controller Comparisons

A=New Installation, B=Retrofit

Simple Payback in Years

Load Horse Power	Situation 1A	1B	2A	3A	4A	4B	5A	5B	6A	6B
5.0	1.22	13.22	0	1.16	16.78	28.22	------no savings--------			
4.5	0.88	8.71	0	0.71	20.08	33.78	-19.37	-19.37	-25.2	-25.5
4.0	0.60	6.55	0	1.24	13.39	22.51	49.81	49.81	-23.3	-23.3
3.75	1.22	13.20	0	1.66	19.73	33.18	104.56	104.56	-149.5	-149.5
3.0	0.65	7.04	0	1.70	12.49	21.0	24.33	24.33	-34.9	-34.9
2.5	0.66	7.16	0	0.98	6.32	10.23	10.68	10.68	17.4	17.4
2.0	0.67	7.28	+23.63	25.95	6.98	11.75	6.62	6.62	23.3	23.3
1.25	0.69	7.48	+12.26	4.33	5.38	9.05	5.45	5.45	10.8	10.8
0.75	0.69	7.48	+7.48	3.90	4.28	7.20	4.30	4.30	7.0	7.0

Table D

10 Horse Power Motor and Controller Comparisons

A= New Installation, B= Retrofit

Simple Payback in Years

Load Horse Power	Situation									
	1A	1B	2A	3A	4A	4B	5A	5B	6A	6B
10	1.15	5.75	NONE	3.27	20.66	33.72	NONE	NONE	-9.45	-9.45
7.5	2.14	10.60	NONE	1.10	11.50	18.77	-14.85	-14.84	67.40	67.40
5.0	3.20	15.98	NONE	2.19	11.24	18.31	50.56	50.56	21.28	21.28
2.5	4.83	24.10	-10.94	14.49	9.42	15.37	8.84	8.84	11.47	11.47

Table E

VI. Conclusions and Recommendations

Conclusions

The analog-digital computer simulation of the PFC and motors is effective for generating the data required for the economic analysis of the "NOLA" controlled motors. The "NOLA Controller" showed an energy savings and effectively controls the power factor of motors operating at less than full load. Although it does conserve energy, the PFC does not provide a cost effective way to conserve energy at this time due to it's high initial cost.

The energy efficient motor proved to be cost effective when used in new installation or scheduled replacement. Retrofitting with energy efficient motors for the purpose of energy conservation is not cost effective.

No conclusions were reached about the effects of the higher harmonics produced by PFC.

The wave shapes of the reflective waves were produced in this thesis and lead one to believe that harmonic problems may be created by the PFC. Additional thoughts on this subject are covered in the recommendation section of this chapter.

Recommendations

Based on the data presented in this thesis and the cost of the PFC, future consideration should be given to the use of the PFC if the initial cost decreases. At the present time energy efficient motors should be used in lieu of

standard induction motors.

The effects of the higher harmonics should be explored. The areas of explanation should be as listed below.

1. The effects of a harmonic dampening device (linear filter) used on the line side of the PFC using different motor load configuration.

2. The effects the harmonics may have on sensistive electronic equipment.

3. The effects of the harmonics on a typical secondary power distribution system versus motor size.

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2. Brockhurst, F. Private Communications June 1979.

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Appendix A

Digital Program to Determine
Motor Element Values And
The ALPHA Values For Controlled
State.

List of Input Variables

M1 = Input Flag

V = Line to Line Voltage

IF = Full Load Current

Pin = No Load Input Power

PIF = Full Load Input Power

PFN = No load Power Factor

Pff = Full Load Power Factor

HP = Full Load Horse Power

RPM = Synchronous Speed

RPMF = Full Load Speed

```
      PROGRAM NINE (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMPLEX Z1,Z2,ZPHI,I1,I2,IPHI,V1,E,RC,XM,VA,IFC,INC,V1C
      COMPLEX X12,V1D,ZSER
      REAL I1L,F1,IF,IL,IFR,IFX,INR,INX    ,IN
       COMMON  R1 , XM , RC
       KKK=0
      READ(5,101) M1
 101   FORMAT(1I1)
      IF (M1.EQ.1) GO TO 200
      READ(5,100) R11,R22,X11,X22,RCC,XMM,RPM,V11
 100  FORMAT(8F9.6)
      V11=V11/SQRT(3.)
      THETA = 0.0
       PRINT*, " "
       PRINT*," R11=  ",R11,"     R22= ",R22
      PRINT*,"  X11=  ",X11,"   X22= ",X22
      PRINT*,"    RCC =",RCC,"  XMM = ",XMM
      PRINT*,"   RPM = ",RPM,"    V11 = ",V11
      PRINT*, " "
       R1=R11
       R2 =R22
      W=2.0*3.141593 * 60.0
       X2=X22
      V1=CMPLX(V11,0.0)
      VMAX=CABS(V1)*SQRT(2.0)
      Z1=CMPLX(R11,X11)
      XM=CMPLX(0.0,XMM)
      RC=CMPLX(RCC,0.0)
      ZPHI=(RC*XM)/(RC+XM)
      GO TO 40
C*******************************************
C          V = L-L VOLTAGE
C         IF = FULL LOAD CURRENT
C       IN = NO LOAD CURRENT
C        PIN = NO LOAD INPUT POWER
C       PIF = FULL LOAD INPUT POWER
C       PFN =  NO LOAD POWER FACTOR
C        PFF = FULL LOAD POWER FACTOR
C     HP = FULL LOAD HORSEPOWER
C        RPM = SYNCHRONOUS SPEED
C        RPMF = FULL LOAD SPEED
 200  READ(5,210) V,IF,IN,PIN,PIF,PFN,PFF,HP,RPM,RPMF
      WRITE(6,220) V,IF,IN,PIN,PIF,PFN,PFF,HP,RPM,RPMF
 210   FORMAT(10F7.4)
 220  FORMAT (10(2X,F9.4))
      V=V/SQRT(3.)
      PIN=PIN/3.
      PIF=PIF/3.
      VAN= PIN/PFN
      VAF = PIF/PFF
      PO = HP* 746./3.
      S= (RPM-RPMF)/RPM
      FLF = PIF-PIN-PO
      THETN = ACOS(PFN)
      THETF = ACOS(PFF)
      IFR = IF*PFF
      IFX = IF* SIN(THETF)
```

```
      INR = IN* PFN
      INX = IN* SIN(THETN)
       IFC = CMPLX( IFR , -IFX)
      INC = CMPLX(INR,-INX)
      V1 = CMPLX(V,0.)
      I2 = IFC-INC
      R2 = PO/(CABS(I2)**2*((1.-S)/S))
      PPOT = CABS(I2)**2*R2
      R1=(PLF-PPOT)/(CABS(IFC)**2)
      ZSER = V1/IFC
      X1R=AIMAG(ZSER)
      V2=0.005*V
      X1=0.05*X1R
       X2=0.001
  240  X1=X1+X2
      X12=CMPLX(0.,X1)
      V1C = IFC*R1+I2*R2/S+X12*(I2+IFC)
      V1D = V1-V1C
      KKK= KKK + 1
      IF(ABS(AIMAG(V1D)).LE.V2) GO TO 250
      IF(X1.LT.2.*X1R) GO TO 240
      X1=0.05*X1R
      X2=X2/2.
       GO TO  240
  250 Z1=CMPLX(R1,X1)
      X2= X1
      E = V1-INC*Z1
      RCC=CABS(E)**2/(PIN-CABS(INC)**2*R1 )
      EX = CABS(E)
      XPM = EX/ INX
      XM = CMPLX(0.,XMM)
      ZPHI = (RCC*XM)/(RCC+XM)
      PMECH = PO
      VMAX = CABS( V1 )* SQRT(2.)
      PRINT*, "  R1=  ",R1,"  R2=   ",R2,  "PO=  ",PO
      PRINT*, " X1=  ",X1,"  XPM=   ",XPM," RCC =  ",RCC
      PRINT*, "     V1C  =  ", V1C
   40 READ(5,110) HP,M,N,J
  110  FORMAT(F10.4,3I2)
       HP=HP/3.0
      PRINT*,"  HP=",HP,"  M=",M," N= ",N,"    J = ",J
      PMECH=HP*746.0
       IF(J.EQ.1)   GO TO 70
      IF(M.EQ.1) GO TO 50
   70  THETAN =0.0
      CALL UNCONT(Z1,ZPHI,V1,R2,X2,RPM,PMECH,RCC,THETAN)
       THETA = THETAN
      IF(J.EQ.1) GO TO 50
      IF(N.EQ.1) GO TO 60
      GO TO 40
   50 CALL CONT(Z1,ZPHI,VMAX,R2,X2,RPM,PMECH,THETA,RCC)
      IF(N.EQ.1) GO TO 60
      GO TO 40
   60  STOP
        END
```

```
SUBROUTINE UNCONT      74/74    OPT=1   PROMP                FTN 4.8+515          11/15/80  07.11.53        PAGE     1

      SUBROUTINE UNCONT(Z1,ZPHI,V1,R2,X2,RPM,PMECH,RCC,THETAN)
      COMPLEX Z1,Z2,ZPHI,I1,I2,IPHI,V1,E,RC,XM,VA
       REAL I1L , R1
       COMMON  R1 , XM , RC
      S=0.0
      S1=0.01
  110 S=S+S1
      RS=R2/S
      Z2=CMPLX(RS,X2)
      I1=V1/(Z1+(ZPHI*Z2)/(ZPHI+Z2))
      E=V1-I1*Z1
      I2=E/Z2
      PMECH1=CABS(I2)**2*R2*(1.-S)/S
      IF(.99*PMECH.LE.PMECH1.AND.PMECH1.LE.1.01*PMECH)GO TO 100
      IF(S.GT.0.2) S1=S1/2.0
      IF(S.GT.0.2) S=0.0
      GO TO 110
  100  PCORE=CABS(E)**2/RCC
      PCU=CABS(I1)**2*R1+CABS(I2)**2*R2
      PIN=PMECH1+PCORE+PCU
      EFF=PMECH1/PIN
      VA=V1*I1
      THETA=ATAN(AIMAG(VA)/REAL(VA))
      PF=COS(THETA)
      VA1=CABS(VA)
      RPM1=(1.-S)*RPM
      I1L=CABS(I1)
      HP=PMECH1/746.0
      THETAN=THETA
      PRINT*, " UNCONT---OUTPUT------------"
      WRITE(6,150)  HP,RPM1, EFF, PF ,VA , PIN , I1L
  150   FORMAT(1X,7F10.4)
       PRINT*, "      -------"
      RETURN
      END


SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
   3  UNCONT

VARIABLES     SN   TYPE            RELOCATION
 221  E            COMPLEX                          235  EFF      REAL
 242  HP           REAL                             217  IPHI     COMPLEX    *UNDEF
 213  I1           COMPLEX                          225  I1L      REAL
 215  I2           COMPLEX                          232  PCORE    REAL
 233  PCU          REAL                             237  PF       REAL
 234  PIN          REAL                               0  PMECH    REAL              F.P.
 231  PMECH1       REAL                               3  RC       COMPLEX           / /
   0  RCC          REAL            F.P.               0  RPM      REAL              F.P.
 241  RPM1         REAL                             230  RS       REAL
   0  R1           REAL            / /                0  R2       REAL              F.P.
 226  S            REAL                             227  S1       REAL
```

```
      SUBROUTINE CCNT(Z1,ZPHI,VMAX,R2,X2,RPP,PMECH,THETA,RCC)
      COMPLEX Z1,Z2,ZPHI,I1,I2,IPHI,V1,E,RC,XM,VA
       REAL I1L , R1
       COMMON  R1 , XM , RC
      PI=3.141593
      SAFE=PI-THETA
      ALPHA = 0.
      ALPHA1=0.05
  120  S = 0.0
      S1=0.01
  110  S=S+S1
       THETO =ABS(THETA)
      RS=R2/S
      Z2=CMPLX(RS,X2)
      V1A=SQRT((VMAX**2/(2.*PI))*(PI-ALPHA+COS(2.*THETO+ALPHA)
     $*SIN( ALPHA)))
      V1=CMPLX(V1A,0.0)
      I1=V1/(Z1+(ZPHI*Z2)/(ZPHI+Z2))
      E=V1-I1*Z1
      I2=E/Z2
      PMECH1=CABS(I2)**2*R2*(1.-S)/S
      IF(.98*PMECH.LE.PMECH1.AND.PMECH1.LE.1.02*PMECH) GO TO 100
      IF (S.GT.0.2) S1=S1/2.0
      IF(S.GT.0.2) S=0.0
      GO TO 110
  100  VA=V1*I1
      THETA1=ATAN(AIMAG(VA)/REAL(VA))
      THETO1 = ABS(THETA1)
      IF(.98*THETO.LE.THETO1.AND.THETO1.LE.1.02*THETO)GO TO 130
      IF(ALPHA.GE.0.9*SAFE) ALPHA1=ALPHA1/2.0
      IF(ALPHA.GE.0.9*SAFE) ALPHA=0.0
      ALPHA=ALPHA+ALPHA1
      GO TO 120
  130  PCORE=CABS(E)**2/RCC
      PCU=CABS(I1)**2*R1+CABS(I2)**2*R2
      PIN = PMECH1+PCORE+PCU
      EFF=PMECH1/PIN
      RPM1=(1.-S)*RPP
      I1L =CABS(I1)
      HP=PMECH1/746.0
      PF=COS(THETA1)
      PRINT*, "   --------- CONT--OUTPUT--------"
       WRITE(6,150) HP , RPM1 ,EFF ,PF ,VA ,PIN ,I1L ,ALPHA ,V1
  150   FORMAT(1X,9F10.4)
        PRINT*, "      --------"
       PRINT*, "----------------------------------------"
      RETURN
      END
```

SYMBOLIC REFERENCE MAP (R=1)

```
HP=1.66666666667  P=0 N= 0     J = 0
UNCONT---OUTPUT------------
  1.6698 1778.3438      .8804      .7103 1414.8340-1402.0727 1414.8340
  7.5801
  -------
 HP=.833333333333  P=0 N= 0     J = 0
UNCONT---OUTPUT------------
   .8278 1789.5938      .8193      .4879  753.8049-1348.5675  753.8049
  5.8172
  -------
 HP=3.33333333333  P=0 N= 0     J = 1
UNCONT---OUTPUT------------
  3.3591 1752.7500      .8870      .8570 2825.1465-1698.8017 2825.1465
 12.4127
  -------
 --------- CONT--OUTPUT--------
  3.3591 1752.7500      .8870      .8570 2825.1465-1698.8017 2825.1465    12.4127    0.0000
 265.5811    0.0000
  --------
-------------------------------------------
 HP=3.   M=1 N= 0      J = 0
 --------- CONT--OUTPUT--------
  3.0279 1755.0000      .8883      .8519 2542.0646-1562.5134 2542.0646    11.5345     .2500
 257.3522    0.0000
  --------
-------------------------------------------
 HP=2.66666666667  P=1 N= 0     J = 0
 --------- CONT--OUTPUT--------
  2.7047 1755.0000      .8883      .8519 2271.4144-1396.1547 2271.4144    10.9599     .5000
 243.2268    0.0000
  --------
-------------------------------------------
 HP=2.5  M=1 N= 0      J = 0
 --------- CONT--OUTPUT--------
  2.5433 1755.0000      .8883      .8519 2135.8175-1312.8083 2135.8175    10.6276     .6000
 235.9939    0.0000
  --------
-------------------------------------------
 HP=2.33333333333  P=1 N= 0     J = 0
 --------- CONT--OUTPUT--------
  2.3663 1755.0000      .8883      .8519 1987.2160-1221.4684 1987.2160    10.2514     .7000
 227.5397    0.0000
  --------
-------------------------------------------
 HP=2.   M=1 N= 0      J = 0
 --------- CONT--OUTPUT--------
  1.9783 1755.0000      .8883      .8519 1661.3739-1021.1853 1661.3739     9.3733     .9000
 209.9593    0.0300
  --------
-------------------------------------------
 HP=1.66666666667  P=1 N= 0     J = 0
 --------- CONT--OUTPUT--------
  1.6719 1755.0000      .8883      .8519 1404.0984 -863.0475 1404.0984     8.6171    1.0500
 191.2641    0.0000
  --------
-------------------------------------------
 HP=1.33333333333  M=1 N= 0     J = 0
 --------- CONT--OUTPUT--------
  1.3221 1752.7500      .8870      .8570 1111.9139 -668.6100 1111.9139     7.7872    1.2500
 166.6143    0.0300
  --------
-------------------------------------------
```

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Appendix B

Tables of Input/Output

Data for Motor Element and

Alpha Values

5 HP Energy Efficient (A)

Input V= 230.0 volts, I Full Load= 12.3 amps, I No Load= 4.54 amps, P_{IN} No Load= 225.0 watts, Power In Full Load= 4288.0, Power Factor NO Load= 0.125, Power Factor Full Load= 0.874, HP= 5.0, RPM= 1800, RPM Full Load= 1751.0

Equivalent CKT Values Calculated R1= o.5037 ohms, R2= 0.3286 ohms, RCC= 254.273 ohms, X1= 0.9623 ohms, X2= X1, XMM= 28.457 ohms

HP	Output Hp	RPM	EFF	PF	P_{IN} watts	I1 Amps	ALPHA	S	V1 volts
5.0	5.04	1748.25	.8801	87.85	4275.63	12.225	0.0	0.02875	132.7
4.5	4.52	1750.5	.881	87.48	3828.27	11.39	0.3	0.0275	128.06
4.0	4.03	1750.5	.881	87.48	3412.59	10.75	0.55	0.0275	120.9
3.75	3.78	1750.5	.881	87.48	3204.99	10.42	0.65	0.0275	117.17
3.0	3.04	1748.25	.8801	87.85	2578.74	9.4	0.95	0.02875	103.1
2.5	2.46	1750.5	.881	87.48	2089.46	8.41	1.10	0.0275	94.6
2.0	2.01	1750.5	.881	87.48	1701.0	7.59	1.25	0.0275	85.4
1.25	1.27	1746.0	.8791	88.17	1079.5	6.23	1.55	0.03	65.4
0.75	0.748	1750.5	.881	88.48	633.6	4.63	1.75	0.0275	52.09

Table F

5 HP Energy Efficient (B)

V	R1	R2	R3	L1	L2
230.0	0.5037	254.273	0.3286	0.9623	28.457

M	ALP	S
0	0.0	0.02875
0	0.3	0.0275
0	0.65	0.0275
1	1.10	0.0275
0	0.95	0.02875
0	1.25	0.0275
0	1.55	0.03
1	1.75	0.0275

Table G

5 HP Standard (A)

Input V= 460.0 volts, I Full Load= 7.06 amps, I No Load= 3.85 amps, P_{IN} No Load= 335.0 watts, Power in Full Load= 4423.0 watts, Power Factor No Load= 0.11, Power Factor Full Load= 0.787 Horse Power= 5.0, RPM= 1800, RPM Full Load= 1747.0

Equivalent CKT Values Calculated R1= 1.6227 ohms, R2= 1.4443 ohms, RCC= 735.012 ohms, X1= 2.9204 ohms, X2= X1, XMM= 66.316 ohms

HP	Output HP	RPM	Eff	PF	P_{in} Watts	I1 Amp	ALPHA	S	V1
5	5.02	1743.75	.8626	79.03	4342.65	6.897	0.0	0.03125	265.58
4.5	4.55	1746.00	.8624	78.23	3937.60	6.5172	0.2	0.03	257.44
4.0	4.02	1746.00	.8624	78.23	3476.13	6.123	0.45	0.03	241.88
3.75	3.759	1746.00	.8624	78.23	3252.16	5.923	0.55	0.03	233.96
3.0	3.033	1746.00	.8624	78.23	2624.83	5.321	0.80	0.03	210.18
2.5	2.508	1743.75	.8626	79.03	2169.02	4.8741	1.00	0.03125	187.69
2.0	1.967	1746.00	.8624	78.23	1704.00	4.2876	1.15	0.03	169.36
1.25	1.268	1741.50	.8627	79.76	1097.10	3.494	1.45	0.0325	131.22
0.75	0.756	1741.5	.8627	79.76	654.21	2.698	1.7	0.0325	101.33

Table H

5 HP Standard (B)

V	R1	R2	R3	L1	L2
460	1.6227	735.012	14443	2.9204	66.316

M	ALP	S
0	0.0	0.03125
0	0.2	0.03
0	0.55	0.03
1	1.0	0.03125
0	0.8	0.03
0	1.15	0.03
0	1.45	0.0325
1	1.70	0.0325

Table I

10 HP Standard (A)

Input V= 460 volts, I Full Load= 12.6 amps, I No Load= 5.1 amps, P_{in} No Load=379.0 watts, P_{IN} Full Load=8533.0 watts, PF No Load= .094, PF Full Load=.852, HP= 10.0, RPM= 1800, RPM Full Load= 1755

Equivalent CKT Values Calculated R1= 1.0555 ohms, R2= .59318 ohms, RCC= 657.776 ohms, X1= 1.985757 ohms, X2= X1, XMM= 50.228416 ohms

HP	Output HP	RPM	Eff	PF	P_{IN} Watts	I1 Amps	ALPHA	S	V1
10.0	10.08	1752.75	.887	85.70	8475.42	12.41	0.00	.02625	265.6
9.0	9.08	1755.0	.8883	85.19	7626.19	11.59	0.25	.025	257.4
8.0	8.11	1755.0	.8883	85.19	6814.24	10.96	0.50	.025	243.3
7.5	7.63	1755.0	.8883	85.19	6407.43	10.63	0.60	.025	235.9
7.0	7.09	1755.0	.8883	85.19	5961.65	10.25	0.70	.025	227.5
6.0	5.93	1755.0	.8883	85.19	4984.12	9.37	0.9	.025	208.1
5.0	5.01	1755.0	.8883	85.19	4212.27	8.62	1.05	.025	191.3
4.0	3.97	1752.75	.887	85.70	3335.73	7.78	1.25	.02625	166.6
3.0	2.96	1755.0	.8883	85.19	2487.97	6.62	1.40	.025	147.0
2.0	1.99	1755.0	.8883	85.19	1668.50	5.42	1.60	.025	120.4
1.0	0.986	1752.75	.887	85.70	828.77	3.88	1.90	.02625	83.1
0.5	0.507	175.75	.887	85.70	426.71	2.79	2.15	.02624	59.59

Table J

10 HP Standard (B)

V	R1	R2	R3	L1	L2
460	1.0555	657.776	0.5932	1.9875	50.2284

M	ALP	S
0	0.0	0.02625
0	0.5	0.025
0	0.7	0.025
1	1.05	0.025
0	1.40	0.025
0	1.60	0.025
0	1.90	0.02625
1	2.15	0.02625

Table K

10 HP Energy Efficient

Input V= 230.0 volts, I Full Load= 24.2 Amps, I No Load=8.16 amps, P_{IN} no load=291.0 watts, Power in full Load= 8354.0 watts, Power Factor No Load= 0.09, P.F. Full Load= .867, HP= 10.0, RPM= 1800, RPM Full Load=1756.0

Equivalent CKT values calculated R1= 0.23682 ohms, R2= 0.14646 ohms, RCC= 200.2742 ohms, X1= 0.624716 ohms, X2= X1, XMM= 15.6945 ohms

HP	Output HP	RPM	EFF	PF	P_{IN} Watts	I1 Amps	ALPHA	S	V1
10.0	10.11	1752.75	.9001	86.99	8382.4	24.18	0.0	.02625	132.8
9.0	9.14	1757.25	.9031	86.41	7548.7	22.14	0.1	.02375	131.5
8.0	8.08	1757.25	.9031	86.41	6678.6	20.82	0.45	.02375	123.74
7.5	7.42	1757.25	.9031	86.41	6131.0	19.95	0.60	.02375	118.5
7.0	6.92	1757.25	.9031	86.41	5716.8	19.26	0.70	.02375	114.48
6.0	6.06	1757.25	.9031	86.41	5038.65	18.08	0.85	.02375	107.48
5.0	4.93	1757.25	.9031	86.41	4072.88	16.26	1.05	.02375	96.6
4.0	4.04	1757.25	.9031	86.41	3343.68	14.73	1.20	.02375	87.55
3.0	3.00	1757.125	.9024	86.58	2481.28	12.81	1.40	.024375	74.58
2.0	1.98	1757.25	.9031	86.41	1632.3	10.29	1.60	.02375	61.17
1.0	1.01	1752.75	.9001	86.99	840.75	7.66	1.90	.02625	42.05
0.5	0.5	1752.75	.9001	86.99	414.99	5.38	2.15	.02625	29.54

Table L

10 HP Energy Efficient (B)

V	R1	R2	R3	L1	L2
230.0	0.23682	200.2742	0.14646	0.624716	15.6945

M	ALP	S
0	0.0	0.02375
0	0.45	0.02375
0	0.70	0.02375
1	1.05	0.02375

Table M

Appendix C

Analog-Digital Simulation

Computer Program

List of Input Variables

V = Phase to Phase Voltage

R1 = Resistance in Ohms

R2 = Resistance in Ohms

L1 = Inductive Reactance

L2 = Inductive Reactance

M = FLAG, if Equal to 0 then New DAta will be Read

S = Slip of Motor

ALP = ALPHA Angle

```
      PROGRAM NINE(PLOT,INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      DIMENSION Y(20),X(20),GA(20),PE(20),XX(4,20),H(3)
      DIMENSION ZZ1(20),ZZ2(20),ZZ3(20),IFL(7)    ,NN(5)
      DIMENSION AC1(545), AC4(545),WT1(545)
      DIMENSION          RE(543),RIM(543),IWK(3420),WK(3420)
      DIMENSION  FREQ(543)
      COMPLEX XO(544)
      REAL L1,L2,L3  ,L12 , L2SQ ,MAG(543) ,PER(350)
C
C   C  SECTION  **1** INSERTION---------------------
C
C       VOLTAGE AND CIRCUIT VALUES -----
      READ (5,107) V,R1,R2,R3,L1,L2
      PRINT*, "V = ",V," R1 = ",R1," R2 =",R2
C     C *** W = 2 * PI * FREQUENCY , T = TIME IN SECONDS.-----*****
      AP = 3.1415926
       W = 2.0 * AP*60.0
      L1=L1/W
       L2= L2/W
C      NF4 IS THE PLOTTER FLAG FOR
C        THE 2ND,3RD, ,AND 4TH PLOT.
       NF4 = 0
C     INPUT ALPHA , SLIP , AND FLAG -- 1--
   40 READ(5,106) M , ALP , S
         PRINT*,     " ALPHA = ",ALP
C      NF3 IS THE OUTPUT FLAG FOR THE THIRD CYCLE OF CURRENT
       NF3 = 0
      T4=0.0
       CUR2=0.0
      NF=1
       AAA=0.
      NX=243
C     TO  ENABLE THE VOLTAGE CONTROLLER SET CONTRL POSITIVE *******
      CONTRL = 1.
C     SET FLAGS NN TO ZERO ROR SUBROUTINE V3CONT
      DO 14 I=1,3
      K = I + 3
       NN(K)= 60
   14   NN(I)=0
       A5P = 6.0* AP
      A7P=19.334283
       A9P = 6.0 * AP
      A9P=2.0*AP+A7P
C
      A = 2.0 * AP / 3.0
C
C     C  **S = SLIP **TO BE ITERATED LATER ---------
C
C     C  CKT  VALUES ---------------
C
      L3=L1
      L12=L1+L2
      L2SQ=L2**2.0
      R4= R3*(1.0 -S)/S
      RT=R3+R2+R4
      RL2= L2* R2 +R2
      RX2= R1*L2
```

```
C     C ** VM = PEAK VOLTAGE -----------------
C
       VM = V* SQRT(2.0) / SQRT(3.0)
C
C     C ***IPNT =  0 HERE IF SUMMARY CURVES ARE DESIRED********
C
C     C***NRUN = NUMBER OF RUNS TO BE MADE ---------------
C
       NRUN = 1
       DO 6 IRUN = 1, NRUN
       IPNT = 0
       WRITE(6,100)
       ISTOP = 4
       KEEP = 1
       IFL(1) =-1
C     C **** NINT = NUMBER OF INTEGRATORS ---***------
C
       NINT = 9
1      IFL(2) = -1
C
2      CALL RKFOUR(NINT,Y,X,GA,PE,XX,H,ZZ1,ZZ2,ZZ3,TIME,PNTS,KEEP,IFL)
       IF(IFL(4)) 3,4,5
3      INIT = 1
       TIME1 = -1.256789
       NC = 1
C     C *** NCC = 1 , PORTION OF PIONTS RELEASED TO SECTION 5----------
C
        NCC = 5
C
C     C **FINTIM = FINISH TIME ****************
C
       FINTIM = 0.1
C     C PTMAX = MAXIMUM NUMBER OF POINTS ****************
C
        PTMAX = 8000
C
C     C** SECTION ** 2 **INSERTIONS -----------
C
C     C ** GA = GAIN OF INTEGRATER ***************
C
       GA(1) =1.0 / L1
       GA(2) =1.0/((L2SQ/L12)-L2)
       GA(3) =1.0 / L3
       GA(4) =GA(1)
       GA(5) =GA(2)
       GA(6) =GA(3)
       GA(7) =GA(1)
       GA(8) =GA(2)
       GA(9) =GA(3)
       WRITE(6,101)
4      IF(TIME-TIME1) 7,8,7
7      TIME1 = TIME
C
C     C ** SECTION ** 3 ** INSERTIONS ******************
C
       WT= W* TIME
       WTAP = WT + A
```

```
      WTAM= WT- A
     .V1T = VM * SIN(WT)
       V2T = VM * SIN(WTAP)
        V3T = VM * SIN(WTAM)
      IF(CONTRL) 13,13,12
C     CALL VOLTAGE CONTROLLER V3CONT
C
 12   CALL V3CONT(ALP,Y,V1T,V2T,V3T,WT,WTAP,WTAM,NN,PNTS)
13     CONTINUE
8      CONTINUE
C      ***************************************************
C
C     C **   SECTION ** 4 **  INSERTIONS ****************
C
C      ***************************************************
C        I1 = Y(1)  ,  I2 = Y(2) ,   I3 = Y(3)     ------
C
C     CUR1 V TOTAL CURRENT FOR PHASE ** 1 **
C
C      ***************************************************
C
C
      X(1)=  V1T -R1*Y(1) +R2*(Y(3)-Y(2))
      X(2)=PX2*Y(1)/L12-V1T*L2/L12+R2*(Y(2)-Y(3))
      X(3)= R2*Y(2) - RT*Y(3)
      X(4)=V2T-R1*Y(4)+R2*(Y(6)-Y(5))
      X(5)=PX2*Y(4)/L12-V2T*L2/L12+R2*(Y(5)-Y(5))
      X(6)=R2*Y(5)-RT*Y(6)
      X(7)=V3T-R1*Y(7)+R2*(Y(9)-Y(8))
      X(8)=RX2*Y(7)/L12-V3T*L2/L12+R2*(Y(8)-Y(9))
      X(9)= R2*Y(8) - RT*Y(9)
C
C      IF  NN FLAG FROM V3CONT IS SET (1) X = 0.
C
      IF(NN(1).EQ.1)  X(1)=0.0
       IF(NN(2).EQ.1)  X(4)=0.0
       IF(NN(3).EQ.1)   X(7)=0.0
       GO TO 2
5     IPR = 0
      NC =NC- 1
      IF (NC) 9,9,10
9     NC =NCC
      IPR = 1
10    IF(TIME.GE.FINTIM.OR.PNTS.GE.PTMAX) ISTOP = 1
      IF ((IPR+ISTOP).EQ.0) GO TO 11
C      ***************************************************
C
C     C** SECTION ** 5 ** INSERTIONS *************
C
C      ***************************************************
C
C      ---IF  -- WT -- IS BETWEEN  SIX AND EIGHT PI OUTPUT DATA-----
C
       IF(ALP) 22,22,23
 22   IF(NF3.EQ.1) GO TO 15
      IF(WT.GT.ASP) GO TO 21
      GO TO 11
```

```
 21     C4=ABS(Y(1))
       .IF(C4.LE.0.1) GO TO 19
       GO TO 11
 23     IF(NF3.EQ.1) GO TO 15
        IF(WT.GT.AEP)  GO TO 18
        GO TO 11
 18     IF(NN(1).EQ.1) GO TO 19
       GO TO 11
 19     NF3=1
       T4=WT-AEP
       T3 = WT + (2.0*AP)
 15     IF(W1.GT.T3) GO TO 11
C
        NF=NF+1
       AC1(NF)=V1T
        WT1(NF)=(WT-(AEP+T4))/AP
       AC4(NF)=Y(1)
C
       C1=ABS(Y(3))
       C2=ABS(Y(6))
       C3=ABS(Y(9))
        PO = C1
       CUR1= PO**2.0*R4
       CUR2=CUR2+CUR1
        CUR3=0.
C
 11     INIT = 0
       IF(ISTOP) 1,1,6
 6     CONTINUE
C
 100    FORMAT(1H1,1X)
 101    FORMAT (5X," TIME , CYS  , CYO  ,  CYS ,  CURT,  VITS ,WTS ")
 105   FORMAT(111,2F10.6)
 107    FORMAT(FF10.6)
C
       PAVE = (CUR2 / NF ) * 3.0
       PRINT*,"  AVERAGE POWER OUT = ", PAVE
       PHP= PAVE/746.
       PRINT*, "  HORSE POWER OUTPUT =  ", PHP
       PRINT*, "     NF  =  ", NF ,"     PNTS =  ",PNTS
       NF1=NF+1
       NF2=NF+2
       WT1(NF1)=0.0
       WT1(NF2)=0.25
       AC1(NF1)=-VM
       AC1(NF2)=2.0*VM / 6.0
       A2=AC1(NF2)
       A1=AC1(NF1)
       AC4(NF1)=-35.0
       AC4(NF2)=11.666
       IF(AAA) 16,16,17
 16    CONTINUE
       PRINT*, "         G"
        NF4 = NF4 + 1
        IF(NF4.GT.1) GO TO 24
        CALL PLOT (0.,2.,-3)
        GO TO 25
```

```
24    CALL PLOT(0.,0.,-3)
      PRINT*,"A"
25    CALL AXIS(0.,0.,10HPI RADIANS,-10,8.,0.,0.,0.25)
      PRINT*,"B"
      CALL AXIS(0.,0.,11HVOLTS (L-N),11,5.,90.,A1,A2)
      PRINT*,"C"
      CALL LINE(WT1,AC1,NF,1,25,2)
      PRINT*,"D"
      CALL LINE(WT1,AC4,NF,1,25,5)
      PRINT*,"E"
      CALL PLOT(0.,6.,3)
      PRINT*," F "
      CALL PLOT(8.,6.,2)
      CALL PLOT(8.,0.,2)
      CALL PLOT(0.,3.,3)
      CALL PLOT(8.,3.,2)
      CALL PLOT(-0.7,0.,-3)
      CALL AXIS(0.,0.,4HAMPS,4,6.,90.,-35.,11.56)
      CALL PLOT(10.,0.,-3)
      CALL PLOTE(N)
C
      DO 20 I=1,NF
      XO(I)=AC4(I)
20    CONTINUE
C
C
C
      CALL FFTCC (XO,NF,IWK,WK)
C
      DO 30 I=1,NF
      RE(I)= REAL(XO(I))
      RIM(I)= AIMAG(XO(I))
      MAG(I)=((RE(I)**2)+(RIM(I)**2))**0.5
30    FREQ(I)=I-1
      DO 50 I = 1,NF
50    PER(I)= 100.0 * (MAG(I)/MAG(2))
      WRITE(6,164)
164   FORMAT("1",20X,"REAL",10X,"IMAG",15X,"MAG",16X,"HARM",16X,"PER",/)
      WRITE(6,165) (I,RE(I),RIM(I),MAG(I),FREQ(I),PER(I),I=1,NX)
165   FORMAT(5X,I5,5X,E14.7,5X,E14.7,5X,E14.7,5X,F8.3,5X,F8.3)
      PRINT*, "      END FFCRT  OUT   A_L-----------"
17    CONTINUE
C       TIME FOR ONE CYCLE =  1/50 SECONDS ****************************
C ----       ONE CYCLE = 2 PI RADS    ********************************
C
      IF(M.EQ.0) GO TO 40
      STOP
      END
```

SYMBOLIC REFERENCE MAP (R=1)

```
      SUBROUTINE RKFOUR(N,Y,X,GAIN,PEAK,XX,H,C1,C2,C3,TIME,PNTS,KEEP,FL)
      DIMENSION Y(20),X(20),GAIN(20),PEAK(20),XX(4,20),
     $H(9),C1(20),C2(20),C3(20),A(8)
      INTEGER FL(7)
      DATA A(1)/0.1/,A(2)/0.0/,A(3)/1.0E8/,A(4)/1.414214/,A(3)/1.03E-4/
      DATA  A(5)/1.0E-2/,A(7)/0.0/,A(8)/3.0/
C
      IF(FL(1)) 1,3,20
    1 DO 2 I=1,N
      Y(I)=0.0
      PEAK(I)=0.0
    2 GAIN(I)=1.0
      TIME=0.0
      PNTS=0.0
      FL(4)=-1
      FL(5)=1
      FL(1)=0
      DO 9 I= 1,8
    9 H(I)=A(I)
       RETURN
    3 Q=H(1)
      FL(4)=1
      FL(7)=H(8)
    4 H(1)=Q
      FL(3)=0
      DO 5 I=1,N
      C2(I)=GAIN(I)*Q
      C1(I)=0.5*C2(I)
    5 C3(I)=C2(I)/6.0
      IF(FL(1)) 6,6,10
   10  IF(FL(2)) 31,33,33
    6 FL(1)=1
    7 PNTS=PNTS+1.0
      DO 8 I=1,N
      XX(3,I)=Y(I)
    8 XX(4,I)=X(I)
      FL(4)=1
      H(9)=TIME
       RETURN
   20 IF(FL(3)) 25,30,25
   25 IF(FL(2)-3) 26,60,60
   26 IF(FL(7)) 21,30,22
   21 Q=H(1)/H(4)
      IF(Q-H(2)) 23,4,4
   23 Q=H(2)
      IF(Q-H(1)) 4,30,4
   22  Q=H(1)*H(4)
      IF(Q-H(3)) 4,4,24
   24 Q=H(3)
      IF(Q-H(1)) 4,30,4
   30 FL(3)=0
      IF(FL(2)) 31,40,45
   31 FL(5)=KEEP
      KEEP=0
      DO 32 I=1,N
      XX(1,I)=XX(3,I)
   32 XX(2,I)=XX(4,I)
```

```
  33   FL(2)=0
       TIME= H(9)+0.5*H(1)
       DO 34 I=1,N
  34   Y(I)=XX(1,I)+C1(I)*XX(2,I)
  35   KEEP = 0
  36   FL(4)=0
        RETURN
  40   FL(2)=1
       DO 41 I=1,N
       XX(3,I)=X(I)
  41   Y(I)=XX(1,I)+C1(I)*X(I)
       GO TO 35
  45   IF(FL(2)-2) 46,48,60
  46   FL(2)=2
       TIME=H(9)+H(1)
       DO 47 I=1,N
       XX(4,I)=X(I)
  47   Y(I)=XX(1,I)+C2(I)*X(I)
       GO TO 35
  48   FL(2)=3
       IF(H(7)) 49,52,52
  49     KEEP=FL(5)
  50   DO 51 I=1,N
  51   Y(I)=XX(1,I)+C3(I)*(XX(2,I)+X(I)+2.*(XX(3,I)+XX(4,I)))
       GO TO 36
  52   ERR=0.0
        DO 56  I=1,N
       ESTERR= C2(I)*ABS(XX(2,I)+X(I)-2.*XX(4,I))
       IF(PEAK(I)) 53,53,54
  54   ESTERR=ESTERR/PEAK(I)
  53   IF(ERR-ESTERR) 55,56,56
  55   ERR=ESTERR
  56    CONTINUE
       IF(ERR-H(6)) 57,57,66
  57   IF(ERR-H(5)) 58,59,59
  58   FL(7)=FL(7)-1
       IF(FL(7)) 65,65,49
  65   FL(3)=1
       GO TO 49
  59   FL(7)=H(8)
       GO TO 49
  66   FL(7)=H(6)
       GO TO 21
  60   IF(H(7)) 7,61,61
  61   DO 63 I=1,N
       ERR=ABS(Y(I))
       IF(ERR-PEAK(I)) 63,63,62
  62   PEAK(I)=ERR
  63   CONTINUE
       GO TO 7
       END
```

```
      SUBROUTINE V3CONT(ALP,Y,V1T,V2T,V3T,WT,WTAP,WTAM,NN,PNTS)
      DIMENSION Y(20), NN(6)
C       SUBROUTINE V3CONT IS THE VOLTAGE CONTROLLER
C     -- Y -- IS THE ARRAY OF CURRENTS FROM SUBROUTINE RKFOUR
C     THE -- NN -- ARRAY ARE THE FLAGS FOR THE THREE VOLTAGES
C     -- PNTS -- IS THE OUTPUT COUNTER FROM RKFOUR
C      ALP  IS ANGLE IN RADIANS FOR VOLTAGE TO BE ZERO
C
C      EACH CONTROLLER V1T , V2T, V3T ,WORKS INDEPENDENTLY
C      AND ARE IDENTICAL IN LOGIC
C
C      ************  CONTROLLER FOR V1T  ***************
C
C     IF THE SCR IS SHUT OFF THEN NN(2)= 1
C      SET VOLTAGE AND CURRENT EQUAL TO 0.0
C
      IF(NN(1).EQ.1) GO TO 1
C
C     THIS IF STATEMENT ALLOWS THE CURRENT
C      TO MOVE AWAY FROM ZERO ONCE THE
C       SCR IS TURNED ON
C
      IF(PNTS.LT.NN(4)) GO TO 3
C      B1 IS THE ABSOLUTE VALUE OF CURRENT --Y(1) --
      B1=ABS(Y(1))
C       SAMPLE  CURRENT ONE TO CHECK FOR ZERO CROSSING
C          IF  TRUE SET FLAG NN(1) = 1
       IF(B1.GT.0.10)GO TO 3
      NN(1)=1
C
C      THE SCR IS TURNED OFF
C      THE T1 TIMER IS SET FOR PERIOD
C      THAT THE SCR IS TO STAY OFF
C      STATEMENT -- 1 --WILL BE FALSE
C
      T1=WT+ALP
    1 IF(WT.GT.T1) GO TO 2
C
C      SET VOLTAGE AND CURRENT TO ZERO
C
      V1T=0.0
      Y(1)=0.0
C
C      RESET POINT COUNTER NN(4)
C
      NN(4)= PNTS + 60
C
C      GO TO PHASE TWO VOLTAGE CONTROLLER
C
      GO TO 3
C
C       SET FLAG NN(1)=0 TO INDICATE
C      THE SCR IS TURNED ON
C
    2 NN(1)=0
C
C      ***********  CONTROLLER FOR  V2T  ***********
```

```
      3   IF(NN(2).EQ.1) GO TO 4
          IF(PNTS.LT.NN(5)) GO TO 6
          B2= ABS(Y(4))
          IF(B2.GT.0.10)GO TO 6
          NN(2) =1
          T2= WTAP + ALP
      4   IF(WTAP.GT.T2) GO TO 5
          V2T=0.0
          Y(4)=0.0
          NN(5)= PNTS + 60
          GO TO 6
      5   NN(2) =0
    C
    C      ************* CONTROLLER FOR  V3T  ************
      6   IF (NN(3).EQ.1) GO TO 7
          IF(PNTS.LT.NN(6)) GO TO 9
          B3= ABS(Y(7))
            IF(B3.GT.0.10)GO TO 9
          NN(3)=1
          T3= WTAM + ALP
      7   IF(WTAM.GT.T3) GO TO 8
          V3T=0.0
          Y(7)=0.0
          NN(5)= PNTS + 60
          GO TO 9
      8   NN(3)=0
      9   RETURN
          END


       SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  V3CONT

VARIABLES      SN   TYPE            RELOCATION
    0  ALP          REAL                 F.P.        114  B1         REAL
  116  B2           REAL                             120  B3         REAL
    0  NN           INTEGER    ARRAY     F.P.          3  PNTS       REAL                  F.P.
  115  T1           REAL                             117  T2         REAL
  121  T3           REAL                               0  V1T        REAL                  F.P.
    0  V2T          REAL                 F.P.          0  V3T        REAL                  F.P.
    0  WT           REAL                 F.P.          0  WTAM       REAL                  F.P.
    0  WTAP         REAL                 F.P.          0  Y          REAL         ARRAY    F.P.

INLINE FUNCTIONS    TYPE    ARGS
       ABS          REAL       1  INTRIN

STATEMENT LABELS
   28  1                              30  2                           31  3
   46  4                              57  5                           51  6
   76  7                             107  8                          111  9
```

```
      SUBROUTINE FFTCC (A,N,IWK,WK)                                     FFTP0670
C                                  SPECIFICATIONS FOR ARGUMENTS         FFTP0680
      INTEGER            N,IWK(1)                                       FFTP0690
      REAL               WK(1)                                          FFTP0700
      COMPLEX            A(N)                                           FFTP0710
C                                  SPECIFICATIONS FOR LOCAL VARIABLES   FFTP0720
      INTEGER            I,IAM,IAP,IBM,IBP,IC,ICC,ICF,ICK,ID,IDM1,II,   FFTP0730
     1                   IJA,IKB,IKT,ILL,IM,IRD,ISF,ISK,ISP,ISS,ITA,ITB,FFTP0740
     2                   J,JA,JF,JJ,JK,K,K0,K1,K2,K3,KA,KB,KD2,KF,KH,KN,FFTP0750
     3                   KT,KTP,L,L1,M,MM,MM1,MP                        FFTP0760
      REAL               CM,SM,C1,C2,C3,S1,S2,S3,C30,RAD,A0,A1,A4,B4,   FFTP0770
     1                   A2,A3,B0,B1,B2,B3,ZERO,HALF,ONE,TWO,Z0(2),     FFTP0780
     2                   Z1(2),Z2(2),Z3(2),Z4(2)                        FFTP0790
      COMPLEX            ZA0,ZA1,ZA2,ZA3,ZA4,AK2                        FFTP0800
      EQUIVALENCE        (ZA0,Z0(1)),(ZA1,Z1(1)),(ZA2,Z2(1)),           FFTP0810
     1                   (ZA3,Z3(1)),(A0,Z0(1)),(B0,Z0(2)),(A1,Z1(1)),  FFTP0820
     2                   (B1,Z1(2)),(A2,Z2(1)),(B2,Z2(2)),(A3,Z3(1)),   FFTP0830
     3                   (B3,Z3(2)),(ZA4,Z4(1)),(Z4(1),A4),(Z4(2),B4)   FFTP0840
      DATA               RAD/6.283185307179586/,                        FFTP0850
     1                   C30/.8660254037844/                            FFTP0860
      DATA               ZERO,HALF,ONE,TWO/0.0,0.5,1.0,2.0/             FFTP0870
C   IMSL ROUTINE NAME   - FFTCC                                         FFTP1010
C                                                                       FFTP1020
C-----------------------------------------------------------------------FFTP1030
C                                                                       FFTP1040
C   COMPUTER            - CDC/SINGLE                                    FFTP1050
C                                                                       FFTP1060
C   LATEST REVISION     - JANUARY 1, 1978                               FFTP1070
C                                                                       FFTP1080
C   PURPOSE             - COMPUTE THE FAST FOURIER TRANSFORM OF A       FFTP1090
C                           COMPLEX VALUED SEQUENCE                     FFTP1100
C                                                                       FFTP1110
C   USAGE               - CALL FFTCC (A,N,IWK,WK)                       FFTP1120
C                                                                       FFTP1130
C   ARGUMENTS    A      - COMPLEX VECTOR OF LENGTH N. ON INPUT A        FFTP1140
C                           CONTAINS THE COMPLEX VALUED SEQUENCE TO BE  FFTP1150
C                           TRANSFORMED. ON OUTPUT A IS REPLACED BY THE FFTP1160
C                           FOURIER TRANSFORM.                          FFTP1170
C                N      - INPUT NUMBER OF DATA POINTS TO BE             FFTP1180
C                           TRANSFORMED. N MAY BE ANY POSITIVE          FFTP1190
C                           INTEGER.                                    FFTP1200
C                IWK    - INTEGER WORK VECTOR OF LENGTH 6*N+150.        FFTP1210
C                           (SEE PROGRAMMING NOTES FOR FURTHER DETAILS) FFTP1220
C                WK     - REAL WORK VECTOR OF LENGTH 6*N+150.           FFTP1230
C                           (SEE PROGRAMMING NOTES FOR FURTHER DETAILS) FFTP1240
C                                                                       FFTP1250
C   PRECISION/HARDWARE  - SINGLE AND DOUBLE/H32                         FFTP1260
C                       - SINGLE/H36,H48,H60                            FFTP1270
C                                                                       FFTP1280
C   REQD. IMSL ROUTINES - NONE REQUIRED                                 FFTP1290
C                                                                       FFTP1300
C   NOTATION            - INFORMATION ON SPECIAL NOTATION AND           FFTP1310
C                           CONVENTIONS IS AVAILABLE IN THE MANUAL      FFTP1320
C                           INTRODUCTION OR THROUGH IMSL ROUTINE UHELP  FFTP1330
C                                                                       FFTP1340
C   REMARKS  1.  FFTCC COMPUTES THE FOURIER TRANSFORM, X, ACCORDING     FFTP1350
C                TO THE FOLLOWING FORMULA:                              FFTP1360
```

```
C                                                                      FFTP0370
C                X(K+1) = SUM FROM J = 0 TO N-1 OF                     FFTP0380
C                         A(J+1)*CEXP((0.0,(2.0*PI*J*K)/N))            FFTP0390
C                FOR K=0,1,...,N-1 AND PI=3.1415...                    FFTP0400
C                                                                      FFTP0410
C              NOTE THAT X OVERWRITES A ON OUTPUT.                     FFTP0420
C           2.  FFTCC CAN BE USED TO COMPUTE                           FFTP0430
C                                                                      FFTP0440
C                X(K+1) = (1/N)*SUM FROM J = 0 TO N-1 OF               FFTP0450
C                         A(J+1)*CEXP((0.0,(-2.0*PI*J*K)/N))           FFTP0460
C                FOR K=0,1,...,N-1 AND PI=3.1415...                    FFTP0470
C                                                                      FFTP0480
C              BY PERFORMING THE FOLLOWING STEPS;                      FFTP0490
C                                                                      FFTP0500
C                   DO 10 I=1,N                                        FFTP0510
C                      A(I) = CONJG(A(I))                              FFTP0520
C                10 CONTINUE                                           FFTP0530
C                   CALL FFTCC (A,N,IWK,WK)                            FFTP0540
C                   DO 20 I=1,N                                        FFTP0550
C                      A(I) = CONJG(A(I))/N                            FFTP0560
C                20 CONTINUE                                           FFTP0570
C                                                                      FFTP0580
C   COPYRIGHT           - 1978 BY IMSL, INC. ALL RIGHTS RESERVED.      FFTP0590
C                                                                      FFTP0600
C   WARRANTY            - IMSL WARRANTS ONLY THAT IMSL TESTING HAS BEEN FFTP0610
C                           APPLIED TO THIS CODE. NO OTHER WARRANTY,   FFTP0620
C                           EXPRESSED OR IMPLIED, IS APPLICABLE.       FFTP0630
C                                                                      FFTP0640
C-----------------------------------------------------------------------FFTP0650
C                                                                      FFTP0660
C                                  FIRST EXECUTABLE STATEMENT          FFTP0670
      IF (N .EQ. 1) GO TO 9005                                         FFTP0680
      K = N                                                            FFTP0690
      M = 0                                                            FFTP0700
      J = 2                                                            FFTP0710
      JJ = 4                                                           FFTP0720
      JF = 0                                                           FFTP0730
C                                  DETERMINE THE SQUARE FACTORS OF N   FFTP0740
      IWK(1) = 1                                                       FFTP0750
    5 I = K/JJ                                                         FFTP0760
      IF (I*JJ .NE. K) GO TO 10                                        FFTP0770
      M = M+1                                                          FFTP0780
      IWK(M+1) = J                                                     FFTP0790
      K = I                                                            FFTP0800
      GO TO 5                                                          FFTP0810
   10 J = J + 2                                                        FFTP0820
      IF (J .EQ. 4) J = 3                                              FFTP0830
      JJ = J * J                                                       FFTP0840
      IF (JJ .LE. K) GO TO 5                                           FFTP0850
      KT = M                                                           FFTP0860
C                                  DETERMINE THE REMAINING FACTORS OF N FFTP0870
      J = 2                                                            FFTP0880
   15 I = K / J                                                        FFTP0890
      IF (I*J .NE. K) GO TO 20                                         FFTP0900
      M = M + 1                                                        FFTP0910
      IWK(M+1) = J                                                     FFTP0920
      K = I                                                            FFTP0930
```

```
      GO TO 15                                                          FFTP1150
   20 J = J + 1                                                         FFTP1160
      IF (J .EQ. 3) GO TO 15                                            FFTP1170
      J = J + 1                                                         FFTP1180
      IF(J.LE.K) GO TO 15                                               FFTP1190
      K = IWK(M+1)                                                      FFTP1200
      IF (IWK(KT+1) .GT. IWK(M+1)) K = IWK(KT+1)                        FFTP1210
      IF(KT.LE.0) GO TO 30                                              FFTP1220
      KTP = KT + 2                                                      FFTP1230
      DO 25  I = 1,KT                                                   FFTP1240
         J = KTP - I                                                    FFTP1250
         M = M+1                                                        FFTP1260
         IWK(M+1) = IWK(J)                                              FFTP1270
   25 CONTINUE                                                          FFTP1280
   30 MP = M+1                                                          FFTP1290
      IC = MP+1                                                         FFTP1300
      ID = IC+MP                                                        FFTP1310
      ILL = ID+MP                                                       FFTP1320
      IRD = ILL+MP+1                                                    FFTP1330
      ICC = IRD+MP                                                      FFTP1340
      ISS = ICC+MP                                                      FFTP1350
      ICK = ISS+MP                                                      FFTP1360
      ISK = ICK+K                                                       FFTP1370
      ICF = ISK+K                                                       FFTP1380
      ISF = ICF+K                                                       FFTP1390
      IAP = ISF+K                                                       FFTP1400
      KD2 = (K-1) / 2 + 1                                               FFTP1410
      IBP = IAP + KD2                                                   FFTP1420
      IAM = IBP + KD2                                                   FFTP1430
      IBM = IAM + KD2                                                   FFTP1440
      MM1 = M-1                                                         FFTP1450
      I = 1                                                             FFTP1460
   35 L = MP - I                                                        FFTP1470
      J = IC - I                                                        FFTP1480
      IWK(ILL+L) = 0                                                    FFTP1490
      IF ((IWK(J-1) + IWK(J)) .EQ. 4) IWK(ILL+L) = 1                    FFTP1500
      IF (IWK(ILL+L) .EQ. 0) GO TO 40                                   FFTP1510
      I = I + 1                                                         FFTP1520
      L = L - 1                                                         FFTP1530
      IWK(ILL+L) = 0                                                    FFTP1540
   40 I = I + 1                                                         FFTP1550
      IF(I.LE.MM1) GO TO 35                                             FFTP1560
      IWK(ILL+1) = 0                                                    FFTP1570
      IWK(ILL+MP) = 0                                                   FFTP1580
      IWK(IC) = 1                                                       FFTP1590
      IWK(ID) = N                                                       FFTP1600
      DO 45  J = 1,M                                                    FFTP1610
         K = IWK(J+1)                                                   FFTP1620
         IWK(IC+J) = IWK(IC+J-1) * K                                    FFTP1630
         IWK(ID+J) = IWK(ID+J-1) / K                                    FFTP1640
         WK(IRD+J) = RAD/IWK(IC+J)                                      FFTP1650
         C1 = RAD/K                                                     FFTP1660
         IF (K .LE. 2) GO TO 45                                         FFTP1670
         WK(ICC+J) = COS(C1)                                            FFTP1680
         WK(ISS+J) = SIN(C1)                                            FFTP1690
   45 CONTINUE                                                          FFTP1700
      MM = M                                                            FFTP1710
```

```
      IF (IWK(ILL+M) .EQ. 1) MM = M - 1                                 FFTP1720
      IF (MM .LE. 1) GO TO 50                                           FFTP1730
      SM = IWK(IC+MM-2) * WK(IRD+M)                                     FFTP1740
      CM = COS(SM)                                                      FFTP1750
      SM = SIN(SM)                                                      FFTP1760
   50 KB = 0                                                            FFTP1770
      KN = N                                                            FFTP1780
      JJ = 0                                                            FFTP1790
      I = 1                                                             FFTP1800
      C1 = ONE                                                          FFTP1810
      S1 = ZERO                                                         FFTP1820
      L1 = 1                                                            FFTP1830
   55 IF (IWK(ILL+I+1) .EQ. 1) GO TO 60                                 FFTP1840
      KF = IWK(I+1)                                                     FFTP1850
      GO TO 65                                                          FFTP1860
   60 KF = 4                                                            FFTP1870
      I = I+1                                                           FFTP1880
   65 ISP = IWK(ID+I)                                                   FFTP1890
      IF (L1 .EQ. 1) GO TO 70                                           FFTP1900
      S1 = JJ * WK(IRD+I)                                               FFTP1910
      C1 = COS(S1)                                                      FFTP1920
      S1 = SIN(S1)                                                      FFTP1930
C                                  FACTORS OF 2, 3, AND 4 ARE           FFTP1940
C                                  HANDLED SEPARATELY.                  FFTP1950
   70 IF (KF .GT. 4) GO TO 140                                          FFTP1960
      GO TO (75,75,90,115), KF                                          FFTP1970
   75 K0 = KB + ISP                                                     FFTP1980
      K2 = K0 + ISP                                                     FFTP1990
      IF (L1 .EQ. 1) GO TO 85                                           FFTP2000
   80 K0 = K0 - 1                                                       FFTP2010
      IF (K0 .LT. KB) GO TO 190                                         FFTP2020
      K2 = K2 - 1                                                       FFTP2030
      ZA4 = A(K2+1)                                                     FFTP2040
      A0 = A4*C1-B4*S1                                                  FFTP2050
      B0 = A4*S1+B4*C1                                                  FFTP2060
      A(K2+1) = A(K0+1)-ZA0                                             FFTP2070
      A(K0+1) = A(K0+1)+ZA0                                             FFTP2080
      GO TO 80                                                          FFTP2090
   85 K0 = K0 - 1                                                       FFTP2100
      IF (K0 .LT. KB) GO TO 190                                         FFTP2110
      K2 = K2 - 1                                                       FFTP2120
      AK2 = A(K2+1)                                                     FFTP2130
      A(K2+1) = A(K0+1)-AK2                                             FFTP2140
      A(K0+1) = A(K0+1)+AK2                                             FFTP2150
      GO TO 85                                                          FFTP2160
   90 IF (L1 .EQ. 1) GO TO 95                                           FFTP2170
      C2 = C1 * C1 - S1 * S1                                            FFTP2180
      S2 = TWO * C1 * S1                                                FFTP2190
   95 JA = KB + ISP - 1                                                 FFTP2200
      KA = JA + KB                                                      FFTP2210
      IKB = KB+1                                                        FFTP2220
      IJA = JA+1                                                        FFTP2230
      DO 110 II = IKB,IJA                                               FFTP2240
         K0 = KA - II + 1                                               FFTP2250
         K1 = K0 + ISP                                                  FFTP2260
         K2 = K1 + ISP                                                  FFTP2270
         ZA0 = A(K0+1)                                                  FFTP2280
```

```
      IF (L1 .EQ. 1) GO TO 100                                          FFTP2290
      ZA4 = A(K1+1)                                                     FFTP2300
      A1 = A4*C1-B4*S1                                                  FFTP2310
      B1 = A4*S1+B4*C1                                                  FFTP2320
      ZA4 = A(K2+1)                                                     FFTP2330
      A2 = A4*C2-B4*S2                                                  FFTP2340
      B2 = A4*S2+B4*C2                                                  FFTP2350
      GO TO 105                                                         FFTP2360
  100 ZA1 = A(K1+1)                                                     FFTP2370
      ZA2 = A(K2+1)                                                     FFTP2380
  105 A(K0+1) = CMPLX(A0+A1+A2,B0+B1+B2)                                FFTP2390
      A0 = -HALF * (A1+A2) + A0                                         FFTP2400
      A1 = (A1-A2) * C30                                                FFTP2410
      B0 = -HALF * (B1+B2) + B0                                         FFTP2420
      B1 = (B1-B2) * C30                                                FFTP2430
      A(K1+1) = CMPLX(A0-B1,B0+A1)                                      FFTP2440
      A(K2+1) = CMPLX(A0+B1,B0-A1)                                      FFTP2450
  110 CONTINUE                                                          FFTP2460
      GO TO 190                                                         FFTP2470
  115 IF (L1 .EQ. 1) GO TO 120                                          FFTP2480
      C2 = C1 * C1 - S1 * S1                                            FFTP2490
      S2 = TWO * C1 * S1                                                FFTP2500
      C3 = C1 * C2 - S1 * S2                                            FFTP2510
      S3 = S1 * C2 + C1 * S2                                            FFTP2520
  120 JA = KB + ISP - 1                                                 FFTP2530
      KA = JA + KB                                                      FFTP2540
      IKB = KB+1                                                        FFTP2550
      IJA = JA+1                                                        FFTP2560
      DO 135 II = IKB,IJA                                               FFTP2570
         K0 = KA - II + 1                                               FFTP2580
         K1 = K0 + ISP                                                  FFTP2590
         K2 = K1 + ISP                                                  FFTP2600
         K3 = K2 + ISP                                                  FFTP2610
         ZA0 = A(K0+1)                                                  FFTP2620
         IF (L1 .EQ. 1) GO TO 125                                       FFTP2630
         ZA4 = A(K1+1)                                                  FFTP2640
         A1 = A4*C1-B4*S1                                               FFTP2650
         B1 = A4*S1+B4*C1                                               FFTP2660
         ZA4 = A(K2+1)                                                  FFTP2670
         A2 = A4*C2-B4*S2                                               FFTP2680
         B2 = A4*S2+B4*C2                                               FFTP2690
         ZA4 = A(K3+1)                                                  FFTP2700
         A3 = A4*C3-B4*S3                                               FFTP2710
         B3 = A4*S3+B4*C3                                               FFTP2720
         GO TO 130                                                      FFTP2730
  125    ZA1 = A(K1+1)                                                  FFTP2740
         ZA2 = A(K2+1)                                                  FFTP2750
         ZA3 = A(K3+1)                                                  FFTP2760
  130    A(K0+1) = CMPLX(A0+A2+A1+A3,B0+B2+B1+B3)                       FFTP2770
         A(K1+1) = CMPLX(A0+A2-A1-A3,B0+B2-B1-B3)                       FFTP2780
         A(K2+1) = CMPLX(A0-A2-B1+B3,B0-B2+A1-A3)                       FFTP2790
         A(K3+1) = CMPLX(A0-A2+B1-B3,B0-B2-A1+A3)                       FFTP2800
  135 CONTINUE                                                          FFTP2810
      GO TO 190                                                         FFTP2820
  140 JK = KF - 1                                                       FFTP2830
      KH = JK/2                                                         FFTP2840
      K3 = IWK(ID+I-1)                                                  FFTP2850
```

```
      K1 = K0 + ISP                                                   FFTP2360
      IF (L1 .EQ. 1) GO TO 150                                        FFTP2370
      K = JK - 1                                                      FFTP2380
      WK(ICF+1) = C1                                                  FFTP2390
      WK(ISF+1) = S1                                                  FFTP2900
      DO 145 J = 1,K                                                  FFTP2910
         WK(ICF+J+1) = WK(ICF+J) * C1 - WK(ISF+J) * S1                FFTP2920
         WK(ISF+J+1) = WK(ICF+J) * S1 + WK(ISF+J) * C1                FFTP2930
  145 CONTINUE                                                        FFTP2940
  150 IF (KF .EQ. JF) GO TO 160                                       FFTP2950
      C2 = WK(ICC+I)                                                  FFTP2960
      WK(ICK+1) = C2                                                  FFTP2970
      WK(ICK+JK) = C2                                                 FFTP2980
      S2 = WK(ISS+I)                                                  FFTP2990
      WK(ISK+1) = S2                                                  FFTP3000
      WK(ISK+JK) = -S2                                                FFTP3010
      DO 155 J = 1,KH                                                 FFTP3020
         K = JK - J                                                   FFTP3030
         WK(ICK+K) = WK(ICK+J) * C2 - WK(ISK+J) * S2                  FFTP3040
         WK(ICK+J+1) = WK(ICK+K)                                      FFTP3050
         WK(ISK+J+1) = WK(ICK+J) * S2 + WK(ISK+J) * C2                FFTP3060
         WK(ISK+K) = -WK(ISK+J+1)                                     FFTP3070
  155 CONTINUE                                                        FFTP3080
  160 K0 = K0 - 1                                                     FFTP3090
      K1 = K0                                                         FFTP3100
      K2 = K0 + K3                                                    FFTP3110
      ZA0 = A(K0+1)                                                   FFTP3120
      A3 = A0                                                         FFTP3130
      B3 = B0                                                         FFTP3140
      DO 175 J = 1,KH                                                 FFTP3150
         K1 = K1 + ISP                                                FFTP3160
         K2 = K2 - ISP                                                FFTP3170
         IF (L1 .EQ. 1) GO TO 165                                     FFTP3180
         K = KF - J                                                   FFTP3190
         ZA4 = A(K1+1)                                                FFTP3200
         A1 = A4*WK(ICF+J)-B4*WK(ISF+J)                               FFTP3210
         B1 = A4*WK(ISF+J)+B4*WK(ICF+J)                               FFTP3220
         ZA4 = A(K2+1)                                                FFTP3230
         A2 = A4*WK(ICF+K)-B4*WK(ISF+K)                               FFTP3240
         B2 = A4*WK(ISF+K)+B4*WK(ICF+K)                               FFTP3250
         GO TO 170                                                    FFTP3260
  165    ZA1 = A(K1+1)                                                FFTP3270
         ZA2 = A(K2+1)                                                FFTP3280
  170    WK(IAP+J) = A1 + A2                                          FFTP3290
         WK(IAM+J) = A1 - A2                                          FFTP3300
         WK(IBP+J) = B1 + B2                                          FFTP3310
         WK(IBM+J) = B1 - B2                                          FFTP3320
         A3 = A1 + A2 + A3                                            FFTP3330
         B3 = B1 + B2 + B3                                            FFTP3340
  175 CONTINUE                                                        FFTP3350
      A(K0+1) = CMPLX(A3,B3)                                          FFTP3360
      K1 = K0                                                         FFTP3370
      K2 = K0 + K3                                                    FFTP3380
      DO 185 J = 1,KH                                                 FFTP3390
         K1 = K1 + ISP                                                FFTP3400
         K2 = K2 - ISP                                                FFTP3410
         JK = J                                                       FFTP3420
```

```
            A1 = A0
            B1 = B0
            A2 = ZERO
            B2 = ZERO
            DO 180  K = 1,KH
               A1 = A1 + WK(IAP+K) * WK(ICK+JK)
               A2 = A2 + WK(IAM+K) * WK(ISK+JK)
               B1 = B1 + WK(IBP+K) * WK(ICK+JK)
               B2 = B2 + WK(IBM+K) * WK(ISK+JK)
               JK = JK + J
               IF (JK .GE. KF) JK = JK - KF
  180       CONTINUE
            A(K1+1) = CMPLX(A1-B2,B1+A2)
            A(K2+1) = CMPLX(A1+B2,B1-A2)
  185 CONTINUE
      IF (KB .GT. KB) GO TO 160
      JF = KF
  190 IF ( I .GE. MM ) GO TO 195
      I = I + 1
      GO TO 55
  195 I = MM
      L1 = 0
      KB = IWK(ID+I-1) + KB
      IF (KB .GE. KN) GO TO 215
  200 JJ = IWK(IC+I-2) + JJ
      IF (JJ .LT. IWK(IC+I-1)) GO TO 205
      I = I - 1
      JJ = JJ - IWK(IC+I)
      GO TO 200
  205 IF (I .NE. MM) GO TO 210
      C2 = C1
      C1 = CM * C1 - SM * S1
      S1 = SM * C2 + CM * S1
      GO TO 70
  210 IF (IWK(ILL+I) .EQ. 1) I = I + 1
      GO TO 55
  215 I = 1
      JA = KT - 1
      KA = JA + 1
      IF(JA.LT.1) GO TO 225
      DO 220  II = 1,JA
         J = KA - II
         IWK(J+1) = IWK(J+1) - 1
         I = IWK(J+1) + I
  220 CONTINUE
C                                   THE RESULT IS NOW PERMUTED TO
C                                   NORMAL ORDER.
  225 IF (KT .LE. 0) GO TO 270
      J = 1
      I = 0
      KB = 0
  230 K2 = IWK(ID+J) + KB
      K3 = K2
      JJ = IWK(IC+J-1)
      JK = JJ
      K3 = KB + JJ
      ISP = IWK(IC+J) - JJ
```

```
  235 K = K8 + JJ                                          FFTP4100
  240 TEM = A(KJ+1)                                        FFTP4110
      A(K1+1) = A(K2+1)                                    FFTP4120
      A(K2+1) = TEM                                        FFTP4130
      K1 = K1 + 1                                          FFTP4140
      K2 = K2 + 1                                          FFTP4150
      IF (K1 .LT. K) GO TO 240                             FFTP4160
      K1 = K1 + ISP                                        FFTP4170
      K2 = K2 + ISP                                        FFTP4180
      IF (K8 .LT. K3) GO TO 235                            FFTP4190
      IF (K8 .GE. K3 + ISP) GO TO 245                      FFTP4100
      K8 = K8 - IWK(ID+J) + JJ                             FFTP4111
      GO TO 235                                            FFTP4120
  245 K3 = IWK(ID+J) + K3                                  FFTP4130
      IF (K3 - KB .GE. IWK(ID+J-1)) GO TO 250              FFTP4140
      K2 = K3 + JK                                         FFTP4150
      JK = JK + JJ                                         FFTP4160
      K8 = K3 - IWK(ID+J ) + JK
        GO TO 235                                           66-7
  250 IF (J .GE. KT) GO TO 260                             FFTP4153
      K = IWK(J+1) + I                                     FFTP4200
      J=J+1                                                 4210
 255  I=I+1                                                 4220
      IWK(ILL+I) = J                                       FFTP4230
      IF (I .LT. K) GO TO 255                              FFTP4240
      GO TO 230                                            FFTP4250
  260 K8 = K3                                              FFTP4260
      IF (I .LE. 0) GO TO 265                              FFTP4270
      J = IWK(ILL+I)                                       FFTP4280
      I = I - 1                                            FFTP4290
      GO TO 230                                            FFTP4300
  265 IF (KB .GE. N) GO TO 270                             FFTP4310
      J = 1                                                FFTP4320
      GO TO 230                                            FFTP4330
  270 JK = IWK(IC+KT)                                      FFTP4340
      ISP = IWK(ID+KT)                                     FFTP4350
      M = M - KT                                           FFTP4360
      K3 = ISP/JK-2                                        FFTP4370
      IF (KT .GE. M-1 ) GO TO 9005                         FFTP4380
      ITA = ILL+KB+1                                       FFTP4390
      ITB = ITA+JK                                         FFTP4400
      IDM1 = ID-1                                          FFTP4410
      IKT = KT+1                                           FFTP4420
      IM = M+1                                             FFTP4430
      DO 275 J = IKT,IM                                    FFTP4440
         IWK(IDM1+J) = IWK(IDM1+J)/JK                      FFTP4450
  275 CONTINUE                                             FFTP4460
      JJ = 0                                               FFTP4470
      DO 290 J = 1,KB                                      FFTP4480
         K = KT                                            FFTP4490
  280    JJ = IWK(ID+K+1) + JJ                             FFTP4500
         IF (JJ .LT. IWK(ID+K)) GO TO 285                  FFTP4510
         JJ = JJ - IWK(ID+K)                               FFTP4520
         K = K + 1                                         FFTP4530
         GO TO 280                                         FFTP4540
  285    IWK(ILL+J) = JJ                                   FFTP4550
         IF (JJ .EQ. J) IWK(ILL+J) = -J                    FFTP4560
```

```
  230 CONTINUE                                                     FFTP4570
C                                  DETERMINE THE PERMUTATION CYCLES FFTP4580
C                                  OF LENGTH GREATER THAN OR EQUAL FFTP4590
C                                  TO TWO.                          FFTP4600
      DO 300  J = 1,KB                                             FFTP4610
         IF (IWK(ILL+J) .LE. 0) GO TO 300                          FFTP4620
         K2 = J                                                    FFTP4630
  295    K2 = IABS(IWK(ILL+K2))                                    FFTP4640
         IF (K2 .EQ. J) GO TO 300                                  FFTP4650
         IWK(ILL+K2) = -IWK(ILL+K2)                                FFTP4660
         GO TO 295                                                 FFTP4670
  300 CONTINUE                                                     FFTP4680
C                                  REORDER A FOLLOWING THE         FFTP4690
C                                  PERMUTATION CYCLES              FFTP4700
      I = 0                                                        FFTP4710
      J = 0                                                        FFTP4720
      KB = 0                                                       FFTP4730
      KN = N                                                       FFTP4740
  305 J = J + 1                                                    FFTP4750
      IF (IWK(ILL+J) .LT. 0) GO TO 305                             FFTP4760
      K = IWK(ILL+J)                                               FFTP4770
      K0 = JK * K + KB                                             FFTP4780
  310 Z4 = A(K0+I+1)                                               FFTP4790
      WK(ITA+I) = A4                                               FFTP4800
      WK(ITB+I) = B4                                               FFTP4810
      I = I + 1                                                    FFTP4820
      IF (I .LT. JK) GO TO 310                                     FFTP4830
      I = 0                                                        FFTP4840
  315 K = -IWK(ILL+K)                                              FFTP4850
      JJ = K0                                                      FFTP4860
      K0 = JK * K + KB                                             FFTP4870
  320 A(JJ+I+1) = A(K0+I+1)                                        FFTP4880
      I = I + 1                                                    FFTP4890
      IF (I .LT. JK) GO TO 320                                     FFTP4900
      I = 0                                                        FFTP4910
      IF (K .NE. J) GO TO 315                                      FFTP4920
  325 A(K0+I+1) = CMPLX(WK(ITA+I),WK(ITB+I))                       FFTP4930
      I = I + 1                                                    FFTP4940
      IF (I .LT. JK) GO TO 325                                     FFTP4950
      I = 0                                                        FFTP4960
      IF (J .LT. K2) GO TO 305                                     FFTP4970
      J = 0                                                        FFTP4980
      KB = KB + ISP                                                FFTP4990
      IF (KB .LT. KN) GO TO 305                                    FFTP5000
 9005 CONTINUE
      RETURN
      END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
3 FFT3D

Appendix D

Figures of the Reflective Waves of the Controlled Motors

5 Horse Power Energy Efficient Motor

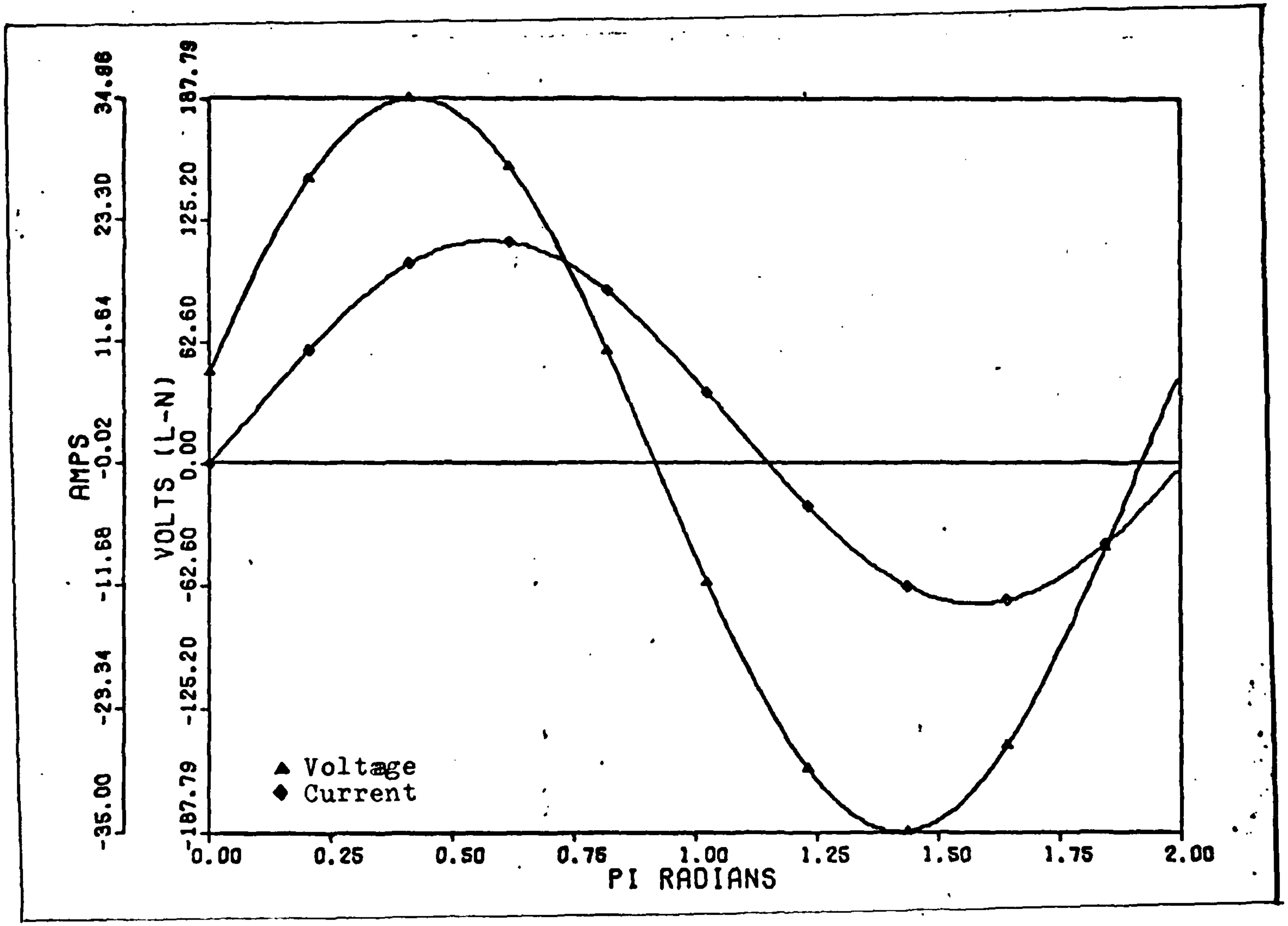


Figure 10

Reflected Voltage and Current Wave for

5 Horse Power Energy Efficient with ALPHA equal 0.0

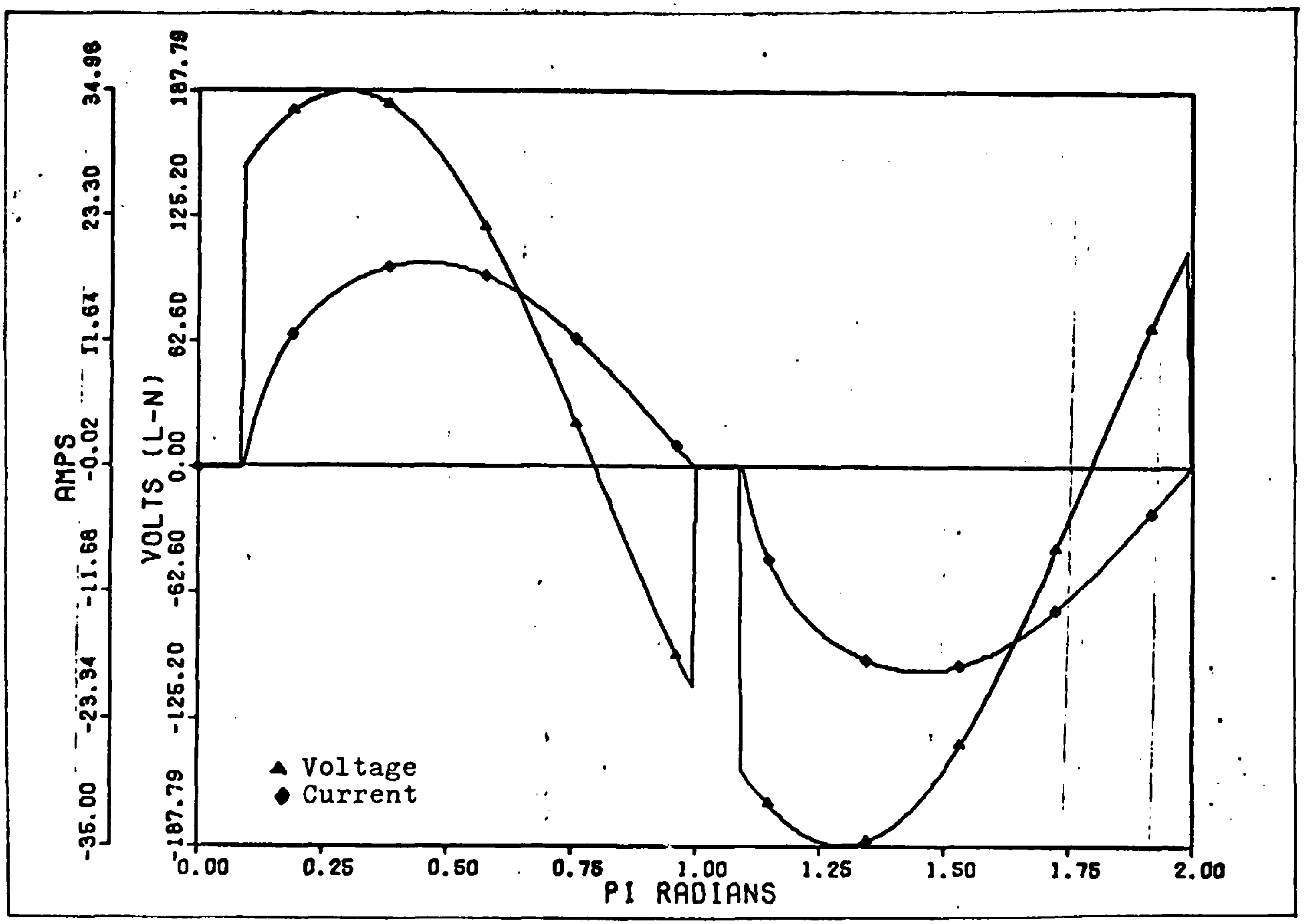


Figure 11

Reflected Voltage and Current Wave for

5 Horse Power Energy Efficient with ALPHA equal 0.3

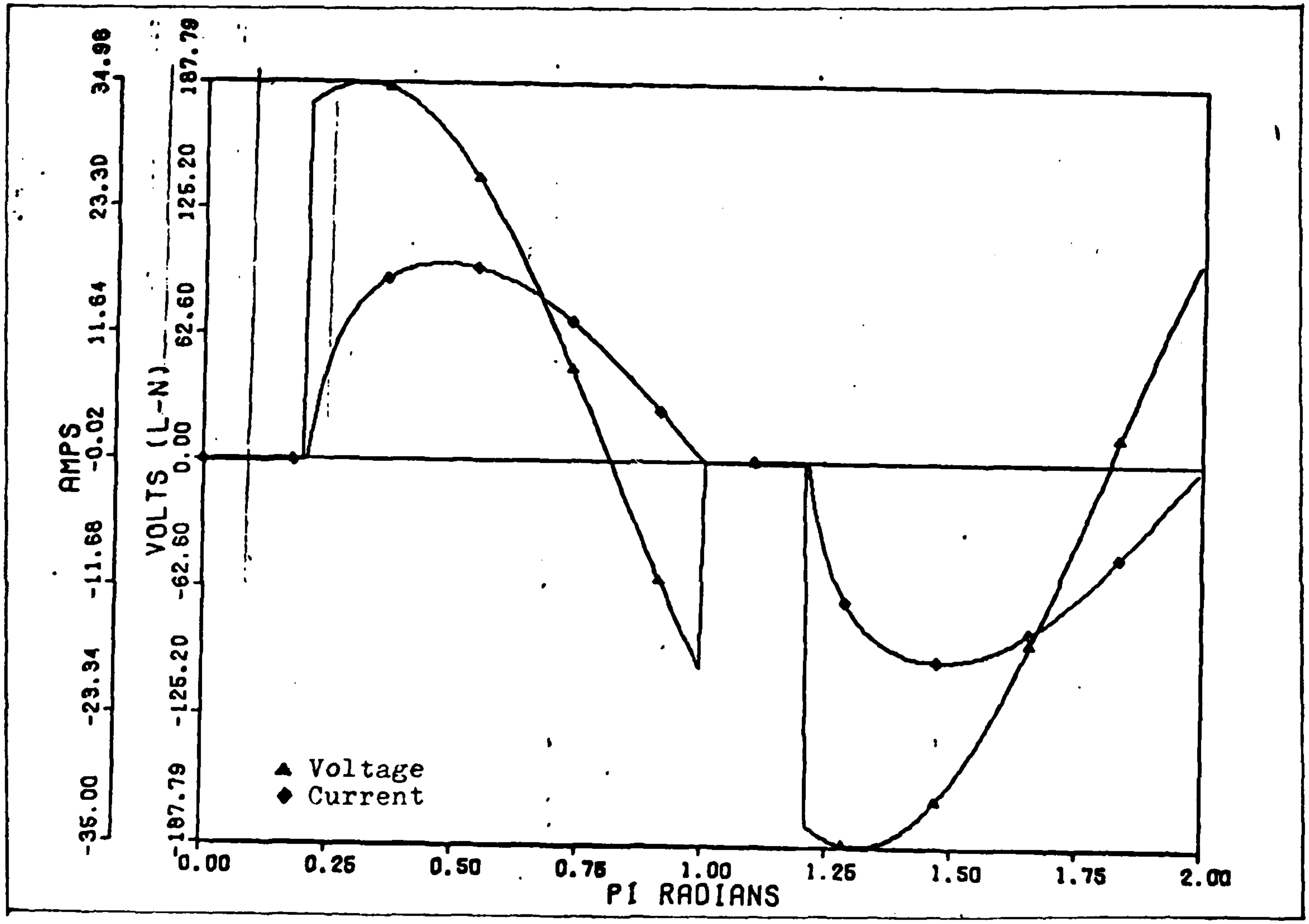


Figure 12

Reflected Voltage and Current Wave for

5 Horse Power Energy Efficient with ALPHA equal 0.65

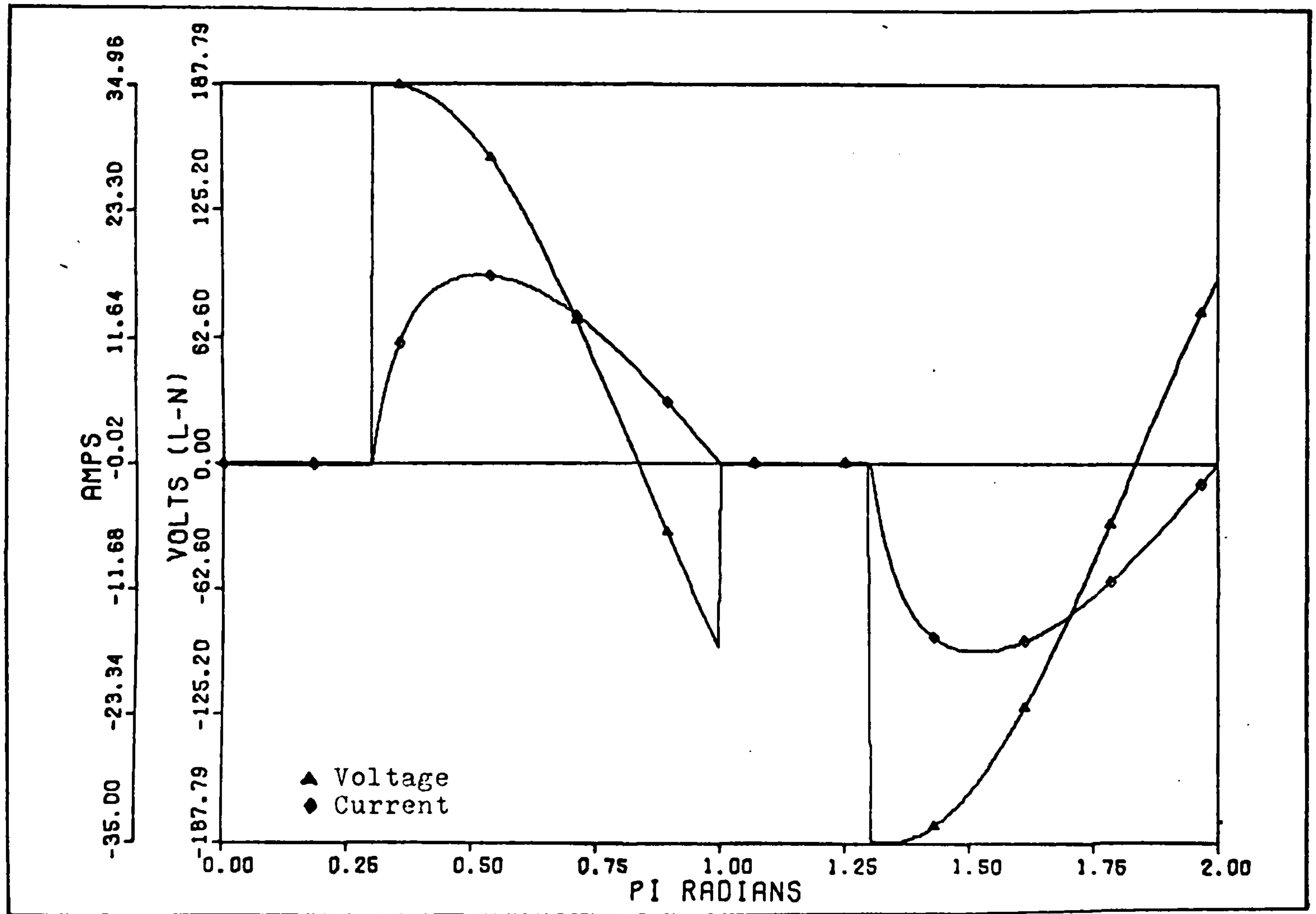


Figure 13

Reflected Voltage and Current Wave for

5 Horse Power Energy Efficient with ALPHA equal 0.95

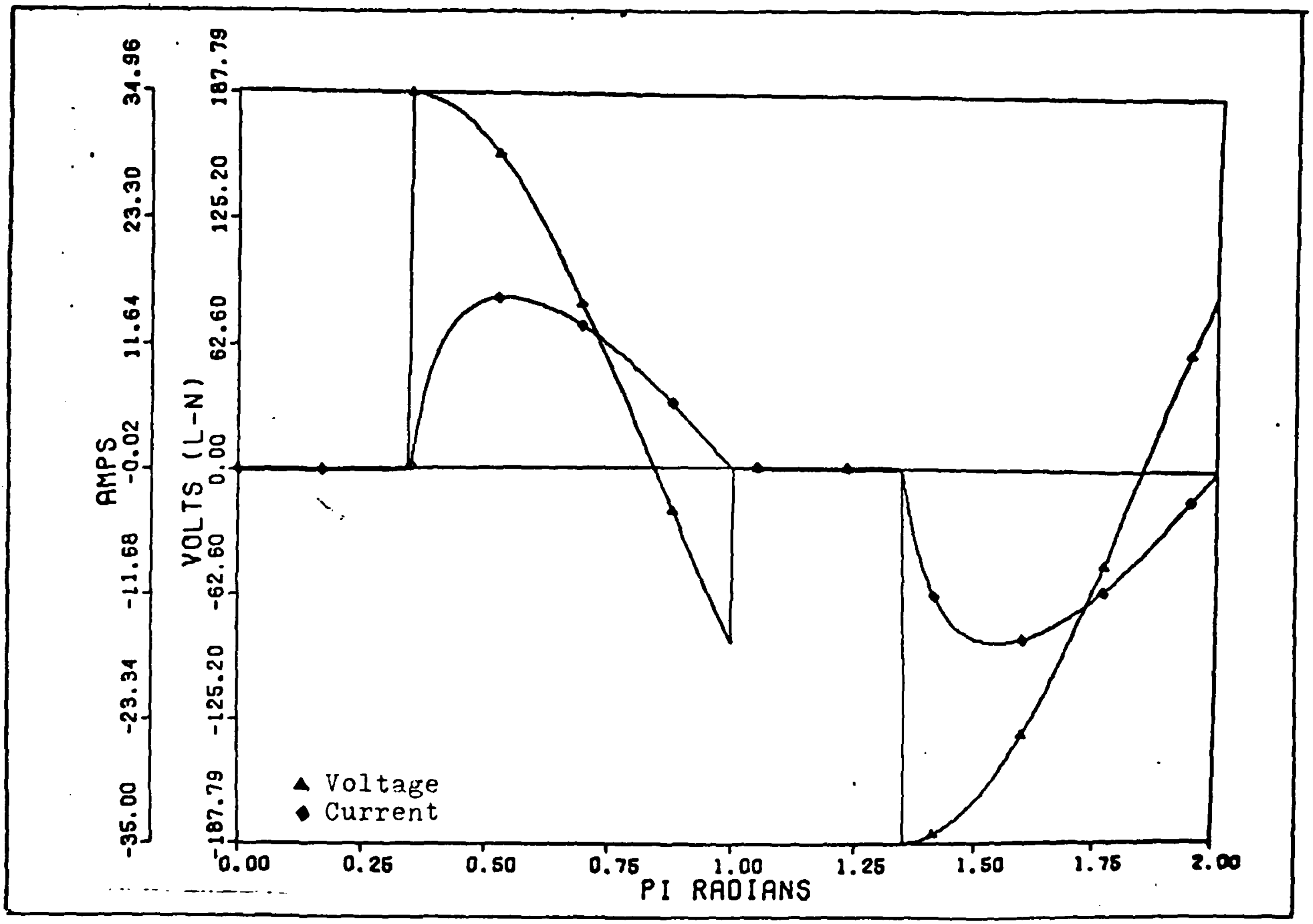


Figure 14

Reflected Voltage and Current Wave for

5 Horse Power Energy Efficient with ALPHA equal 1.10

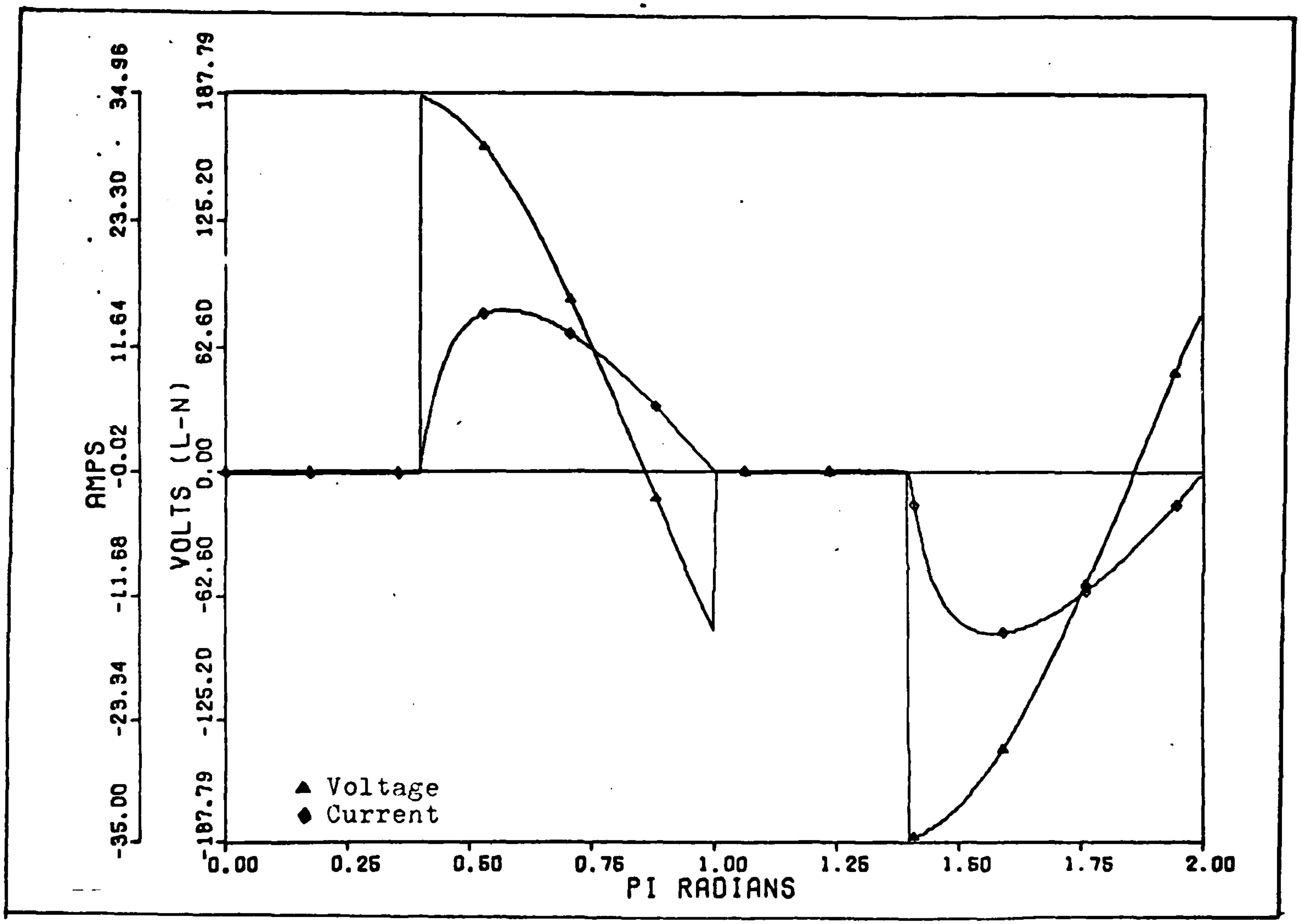


Figure 15

Reflected Voltage and Current Wave for

5 Horse Power Energy Efficient with ALPHA equal 1.25

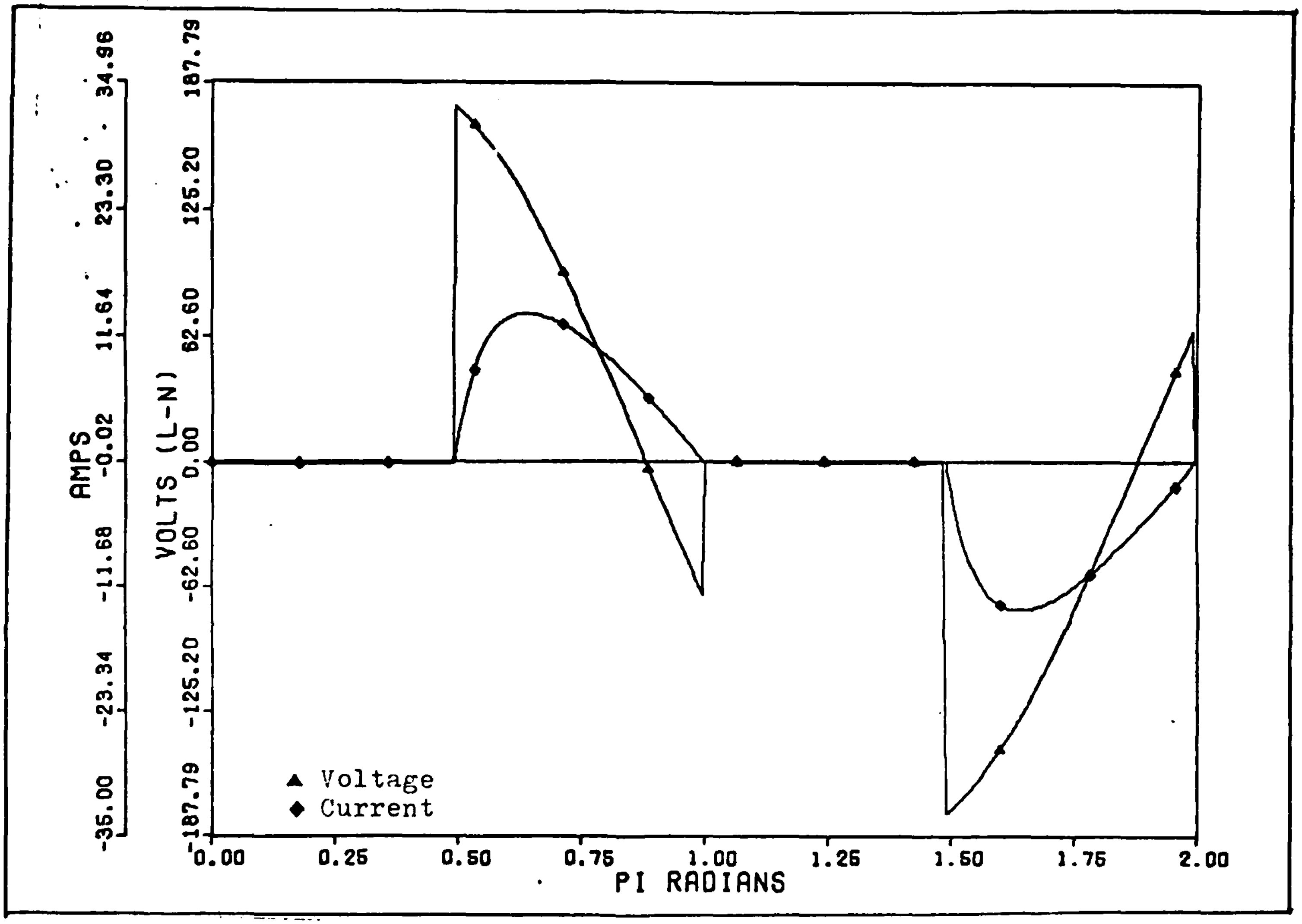


Figure 16

Reflected Voltage and Current Wave for

5 Horse Power Energy Efficient with ALPHA equal 1.55

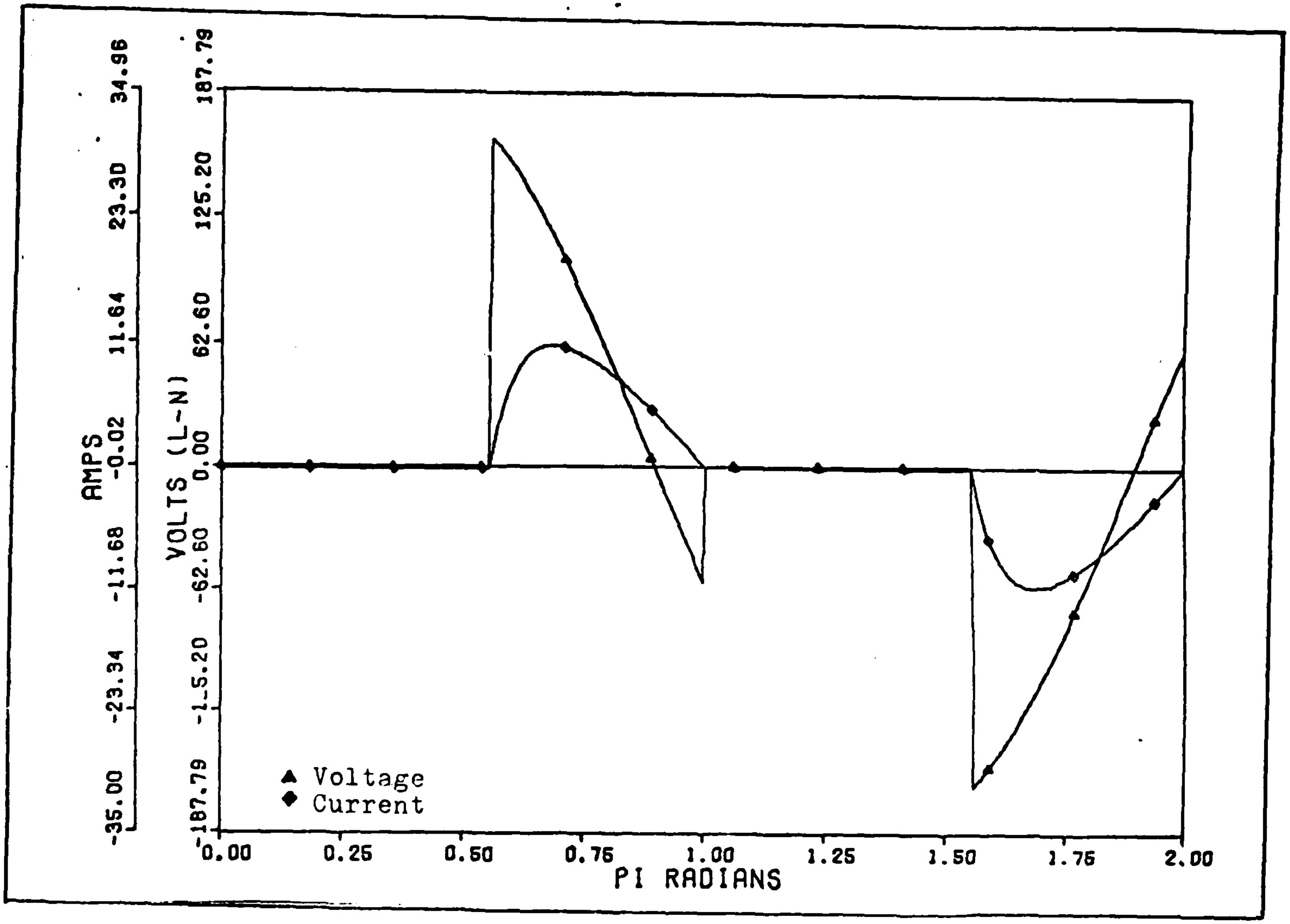


Figure 17

Reflected Voltage and Current Wave for

5 Horse Power Energy Efficient with ALPHA 1.75

5 Horse Power Standard Motor

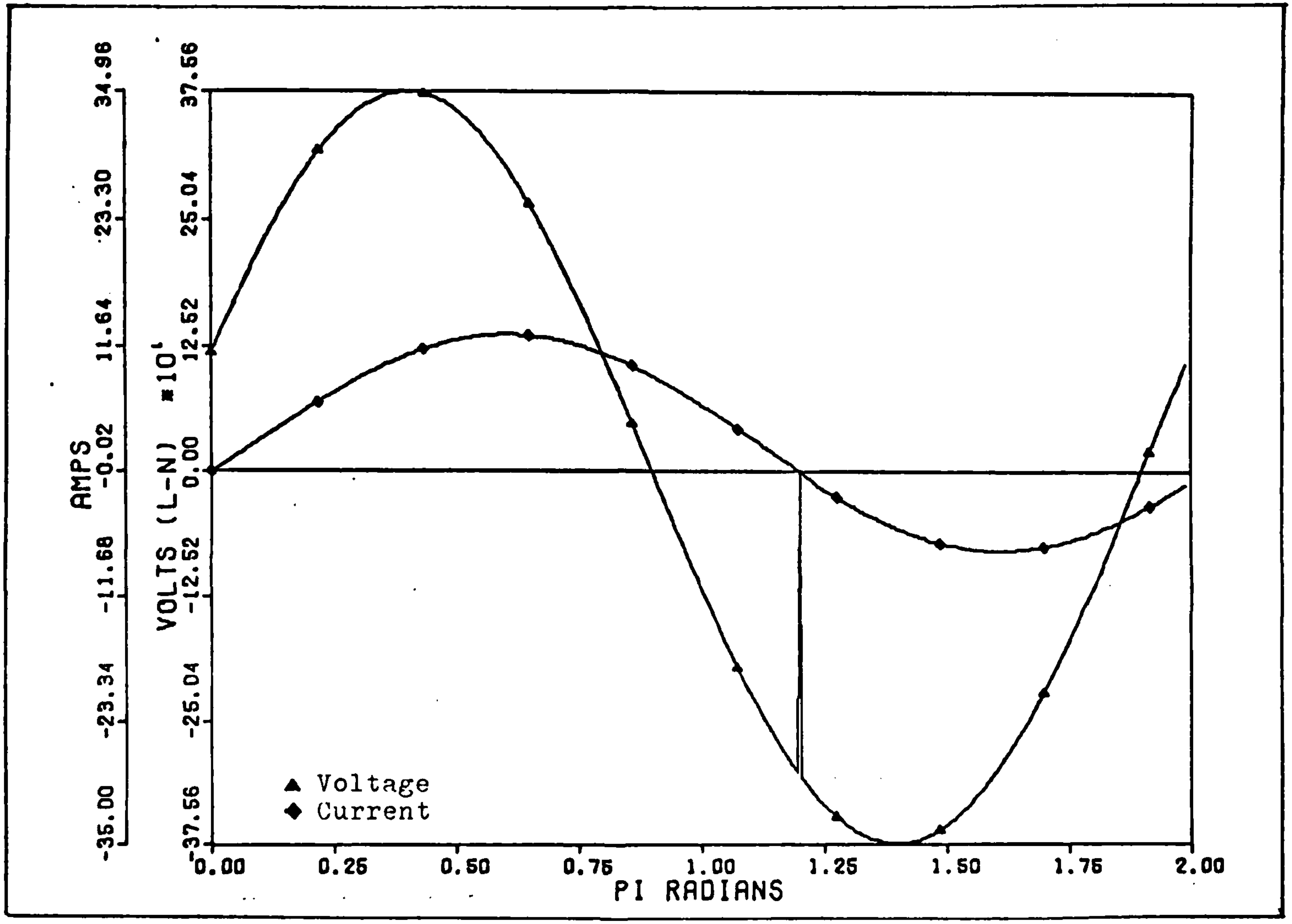


Figure 18

Reflected Voltage and Current Wave for

5 Horse Power Standard with ALPHA equal 0.0

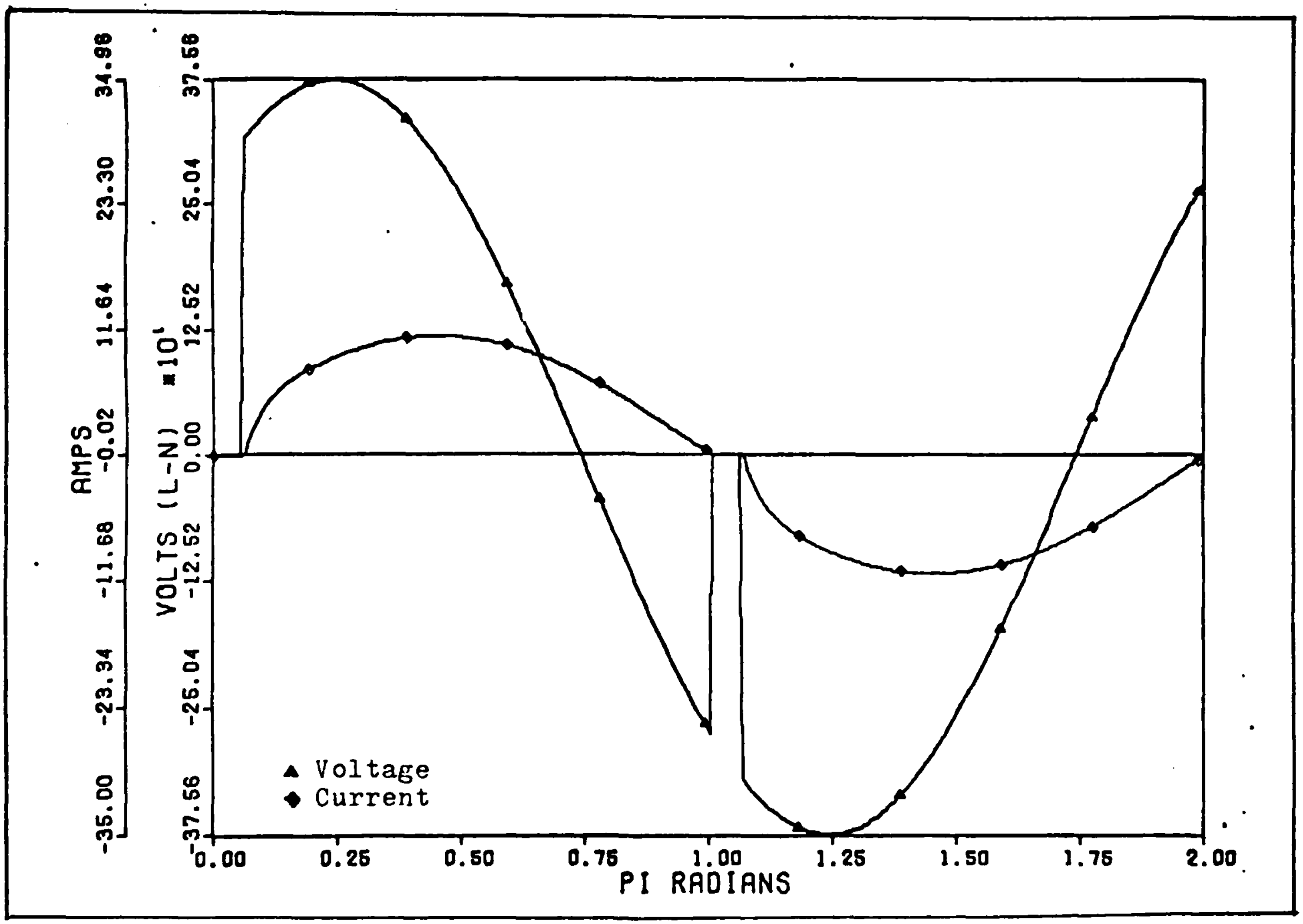


Figure 19

Reflected Voltage and Current Wave for

5 Horse Power Standard with ALPHA equal 0.2

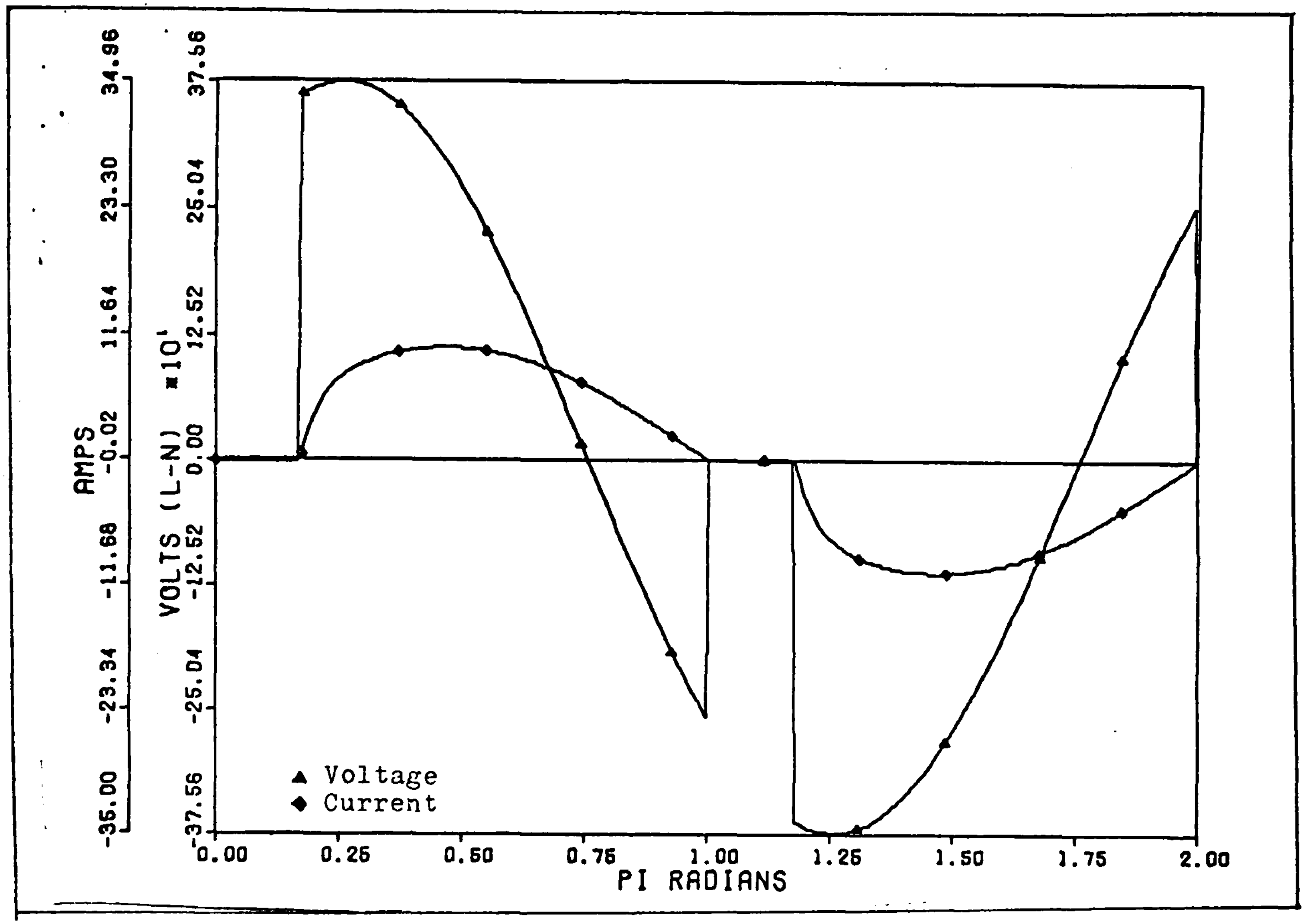


Figure 20

Reflaected Voltage and Current Wave for

5 Horse Power Standard with ALPHA equal 0.55

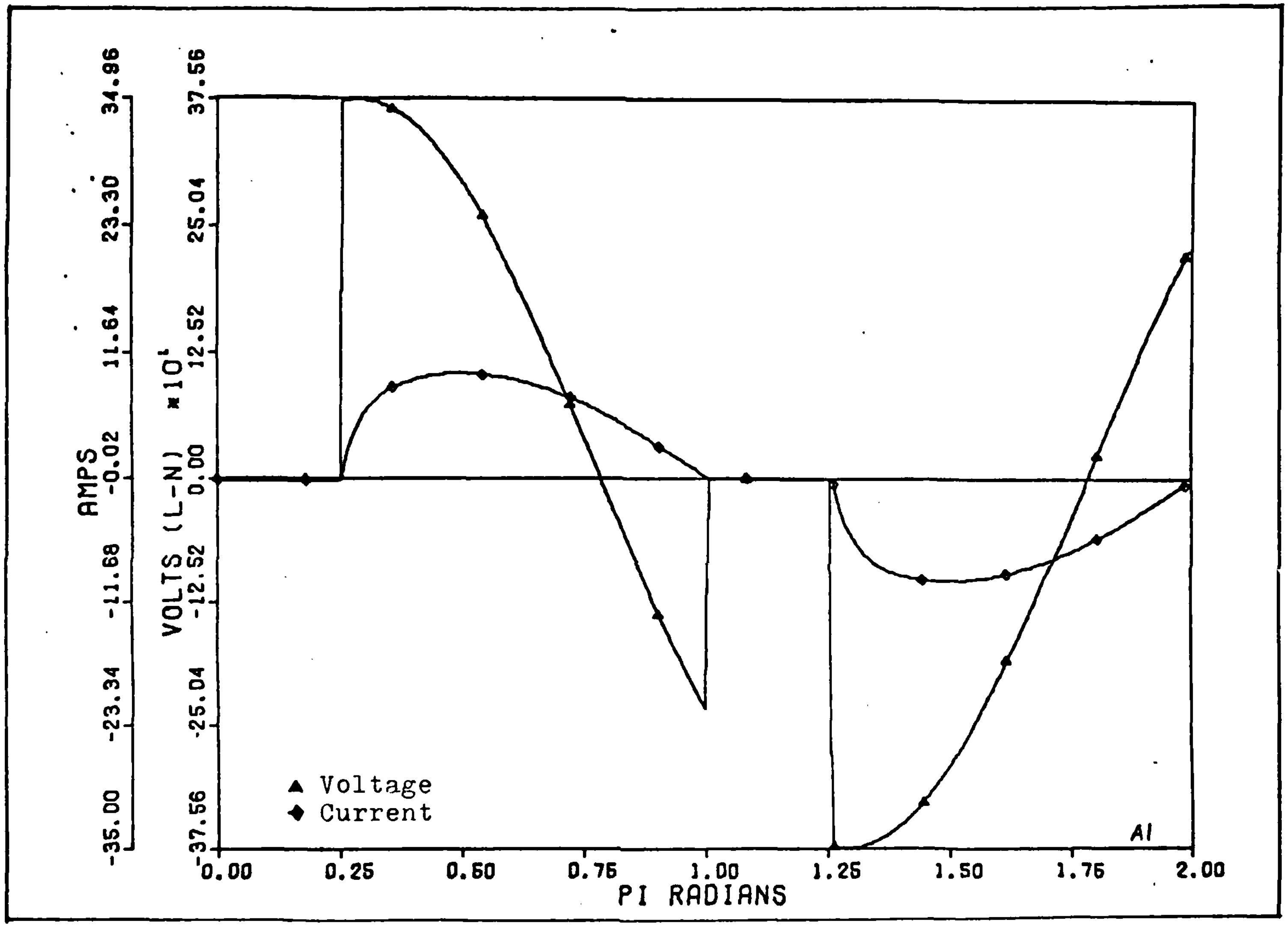


Figure 21

Reflected Voltage and Current Wave for

5 Horse Power Standard with ALPHA equal 0.8

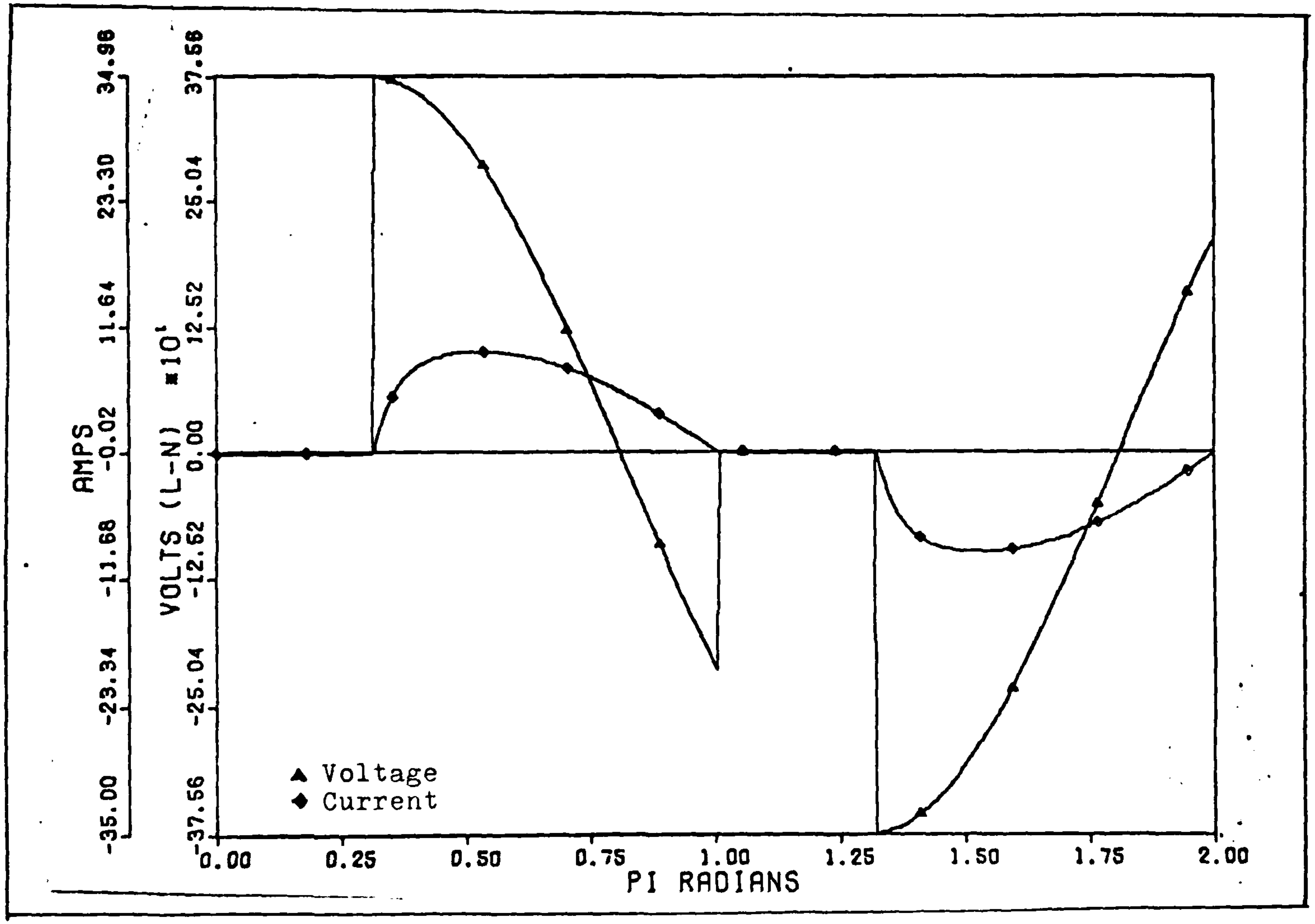


Figure 22

Reflected Voltage and Current Wave for

5 Horse Power Standard with ALPHA equal 1.0

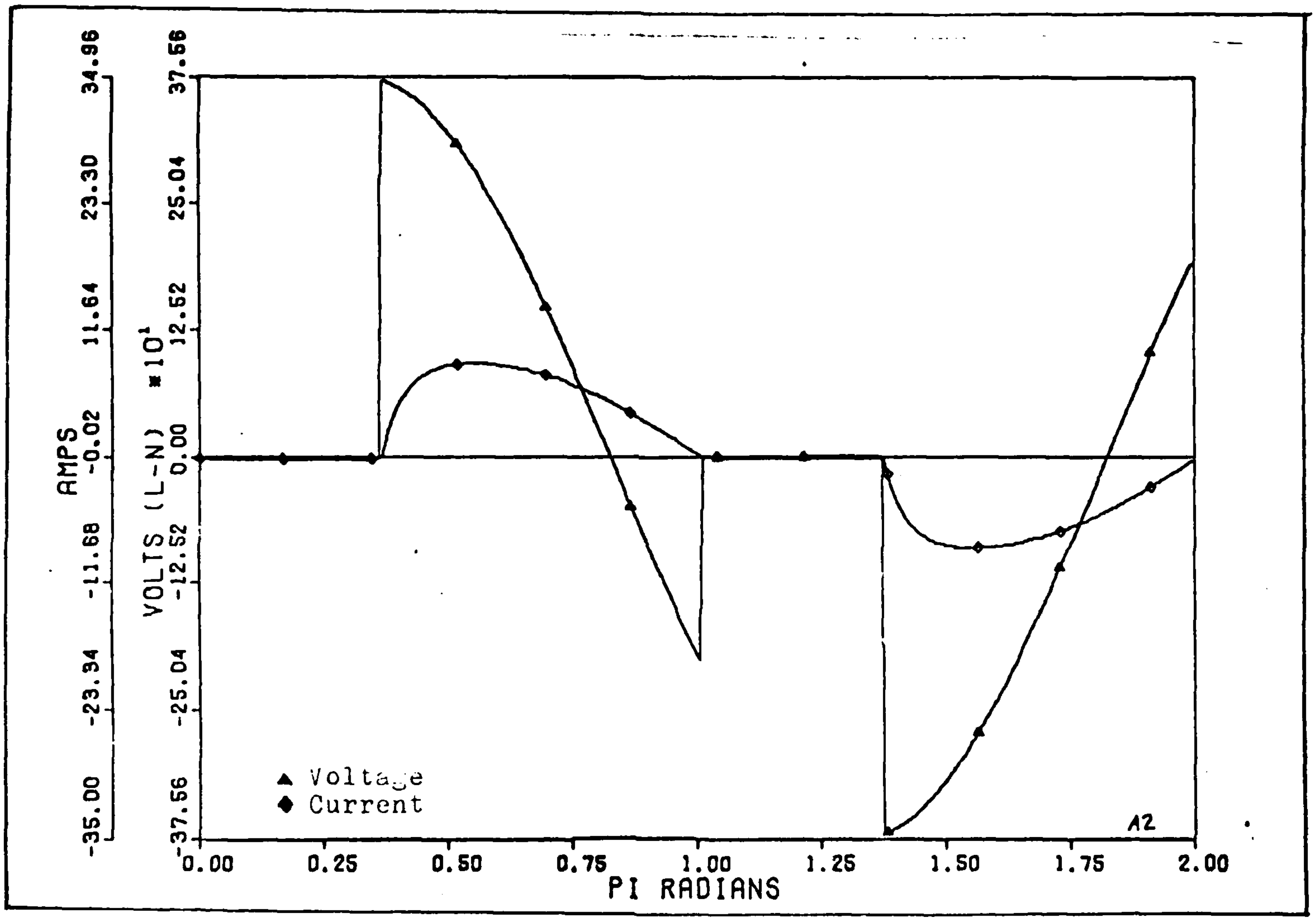


Figure 23

Reflected Voltage and Current Wave for

5 Horse Power Standard with ALPHA equal 1.15

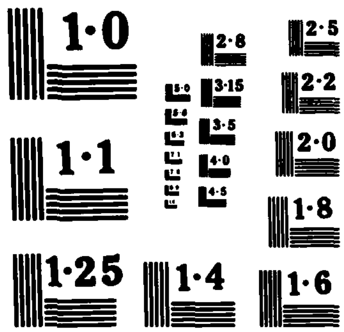
AD-A144 798 COST EFFECTIVENESS OF 'NOLA' CONTROLLED MOTORS INCLUDING EFFECT OF HIGHER HARMONICS(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF ENGI.. 2/2

UNCLASSIFIED R D MCMASTER DEC 80 AFIT/GE/EE/84S-10 F/G 9/3 NL

END

FILMED

DTIC


1·0
2·8
2·5
3·15
2·2
3·5
1·1
2·0
4·0
4·5
1·8
1·25
1·4
1·6

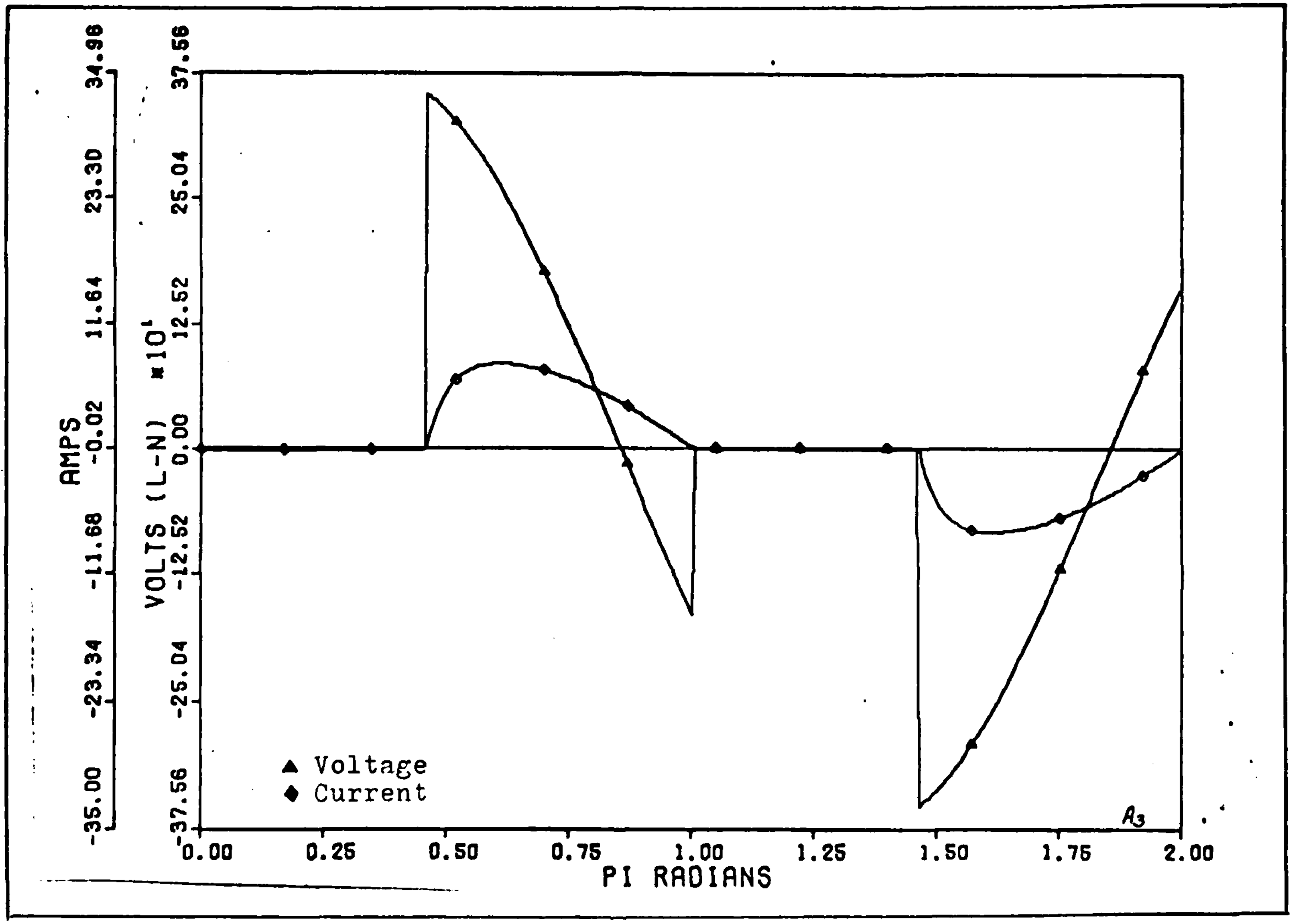


Figure 24

Reflected Voltage and Current Wave for

5 Horse Power Standard with ALPHA equal 1.45

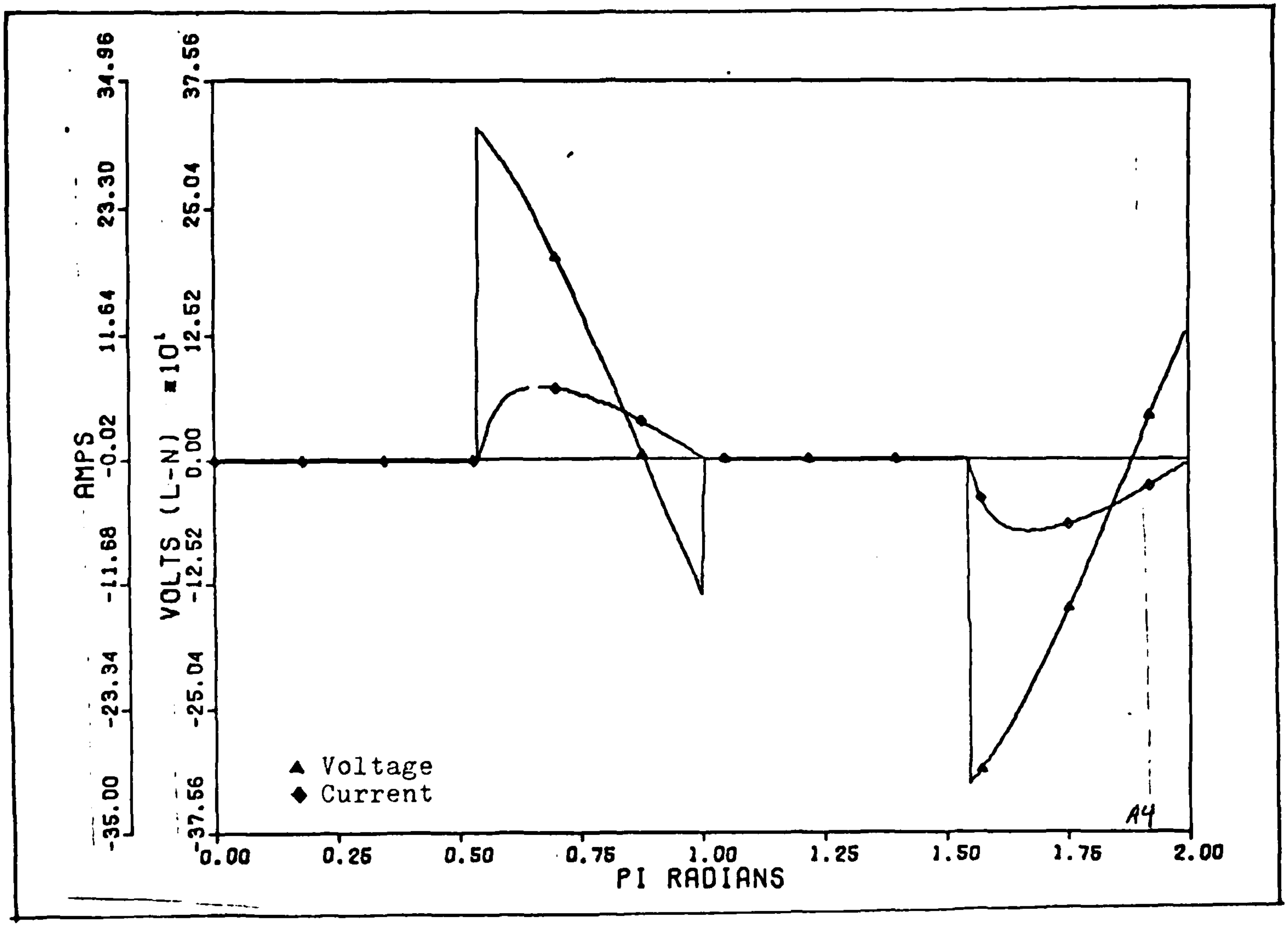


Figure 25

Reflected Voltage and Current Wave for

5 Horse Power Standard with ALPHA equal 1.7

10 Horse Power Energy Efficient Motor

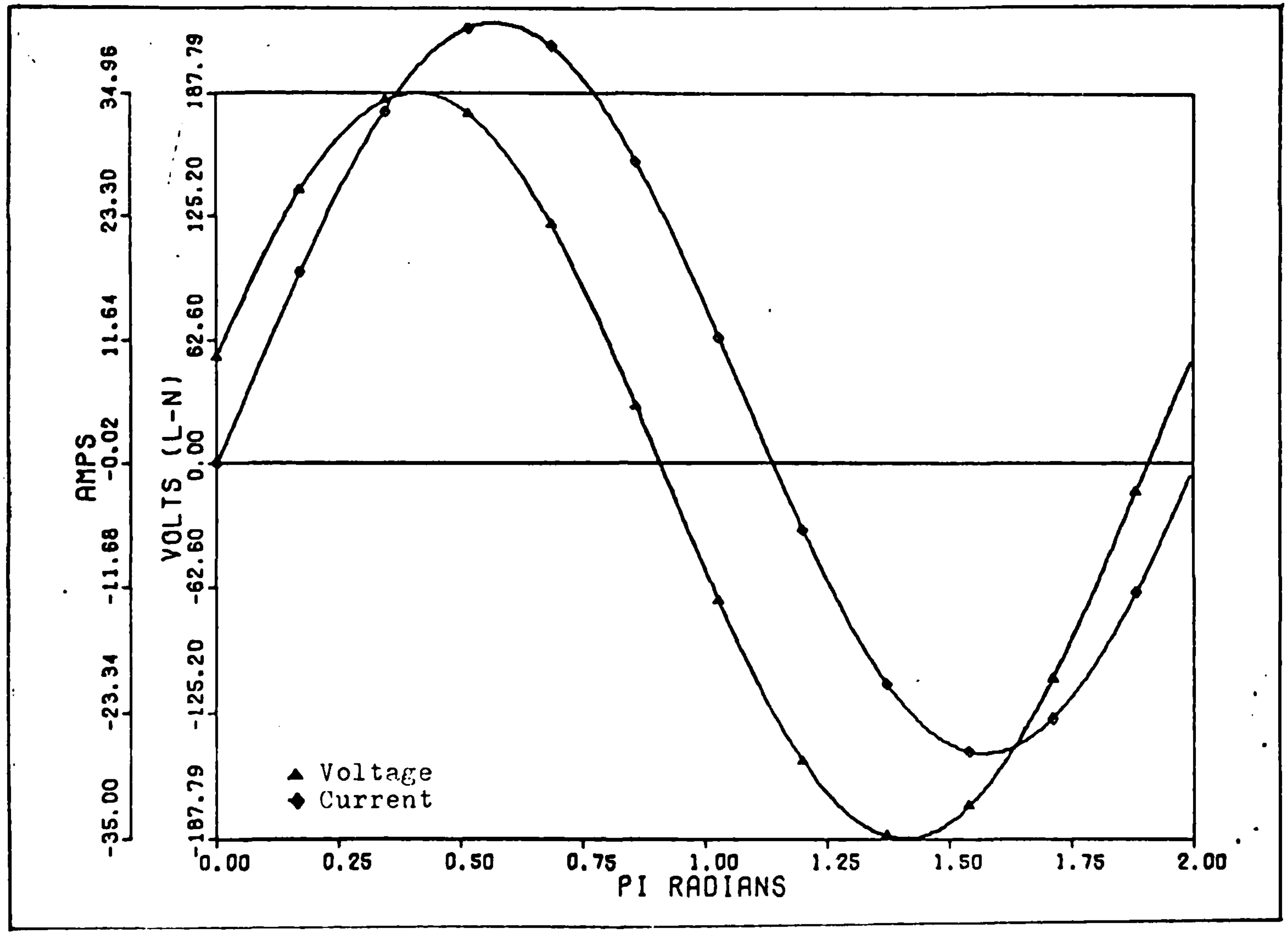


Figure 26

Reflected Voltage and Current Wave for

10 Horse Power Energy Efficient with ALPHA equal 0.0

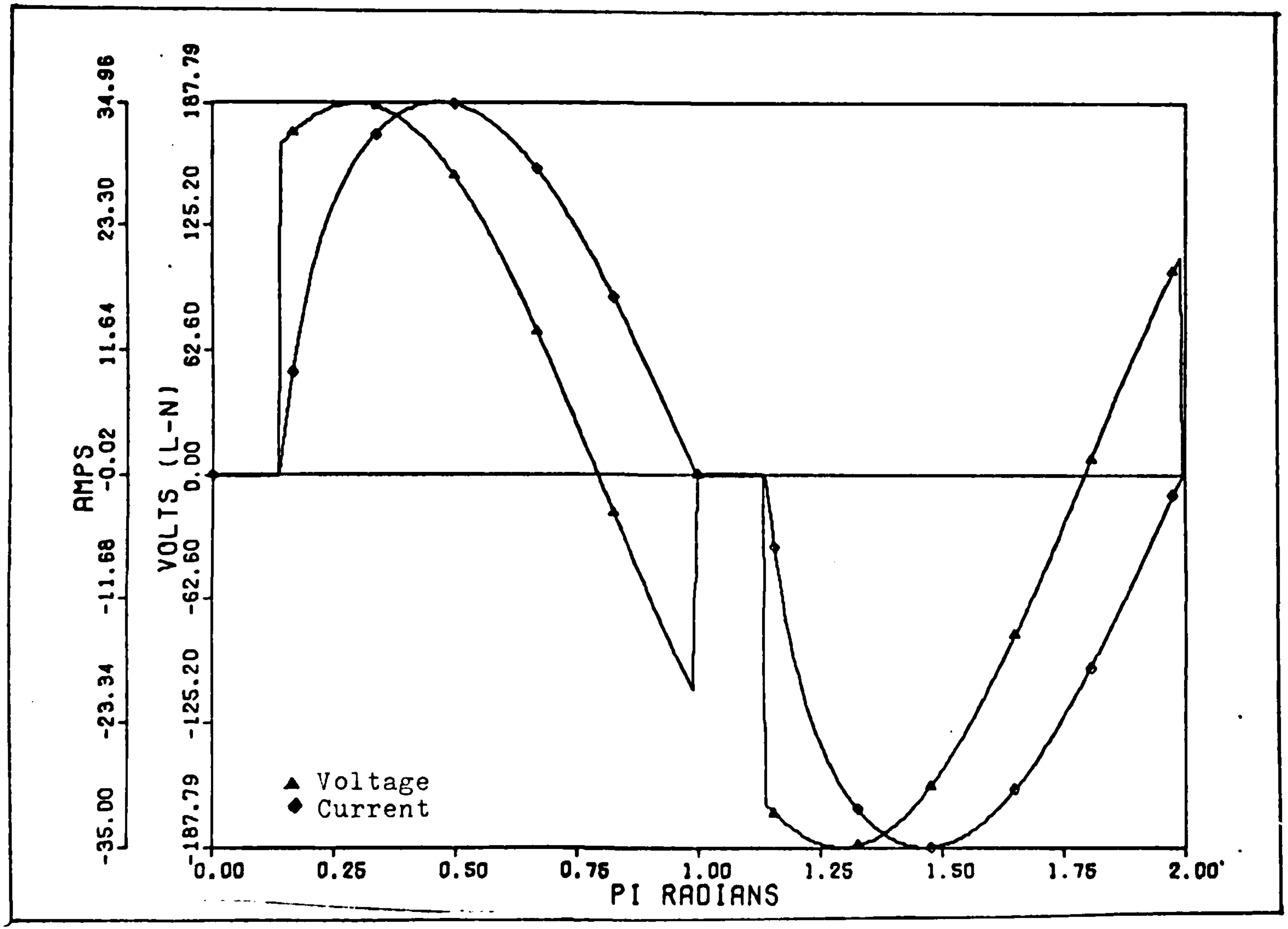


Figure 27

Reflected Voltage and Current Wave for

10 Horse Power Energy Efficient with ALPHA equal 0.45

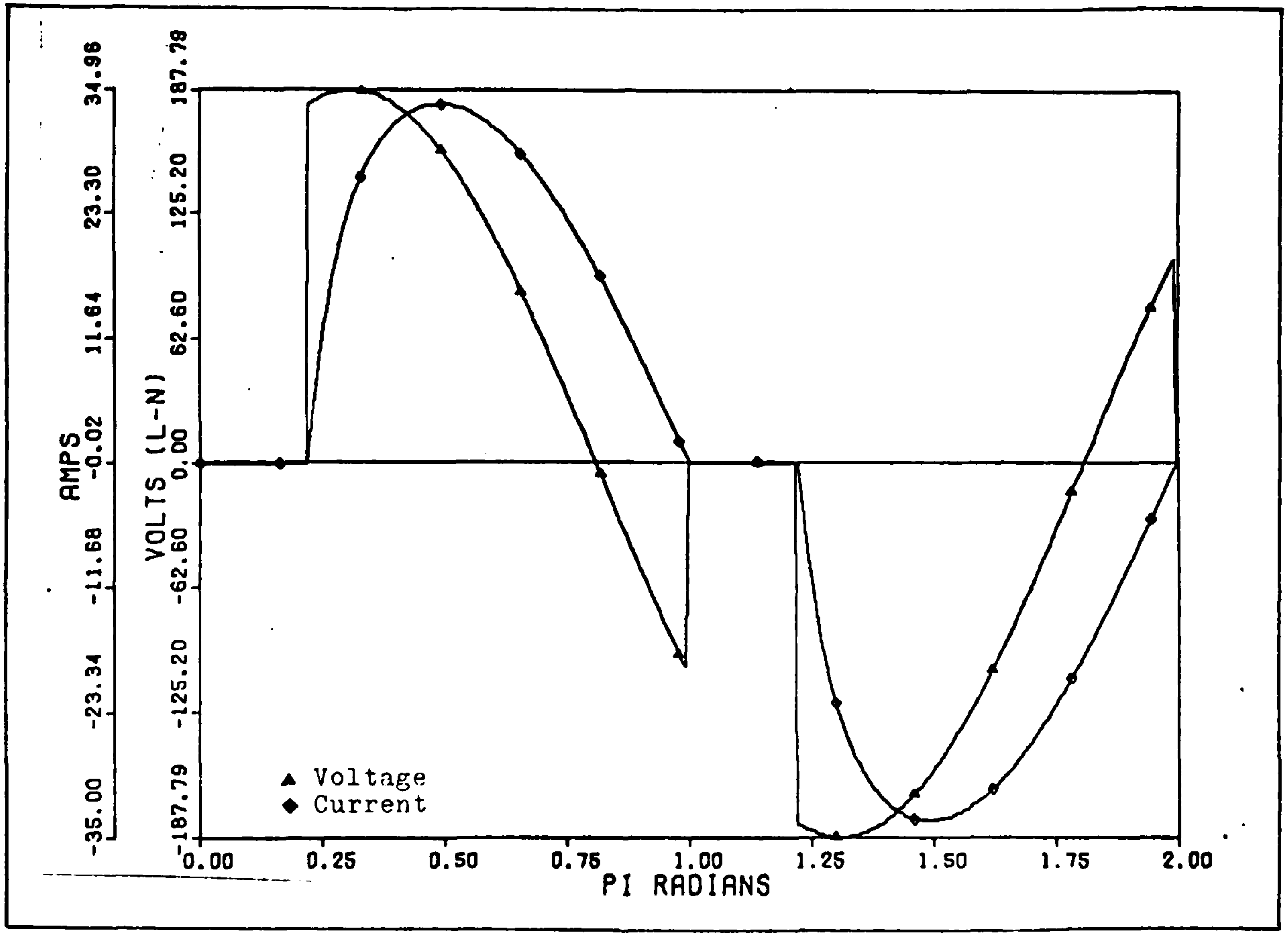
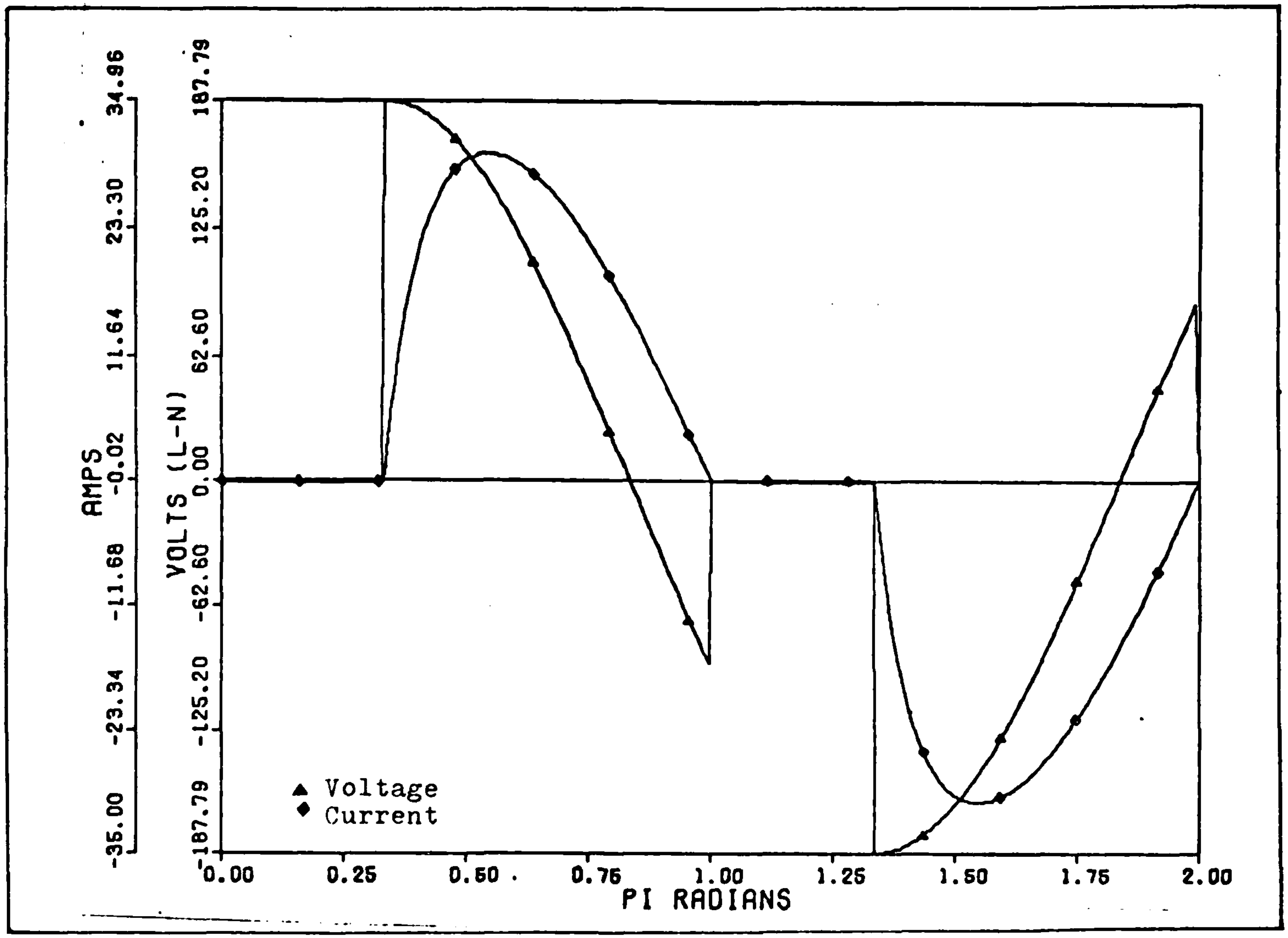


Figure 28

Reflected Voltage and Current Wave for

10 Horse Power Energy Efficient with ALPHA equal 0.7



Reflected Voltage and Current Wave for

10 Horse Power Energy Efficient with ALPHA equal 1.05

Figure 29

10 Horse Power Standard Motor

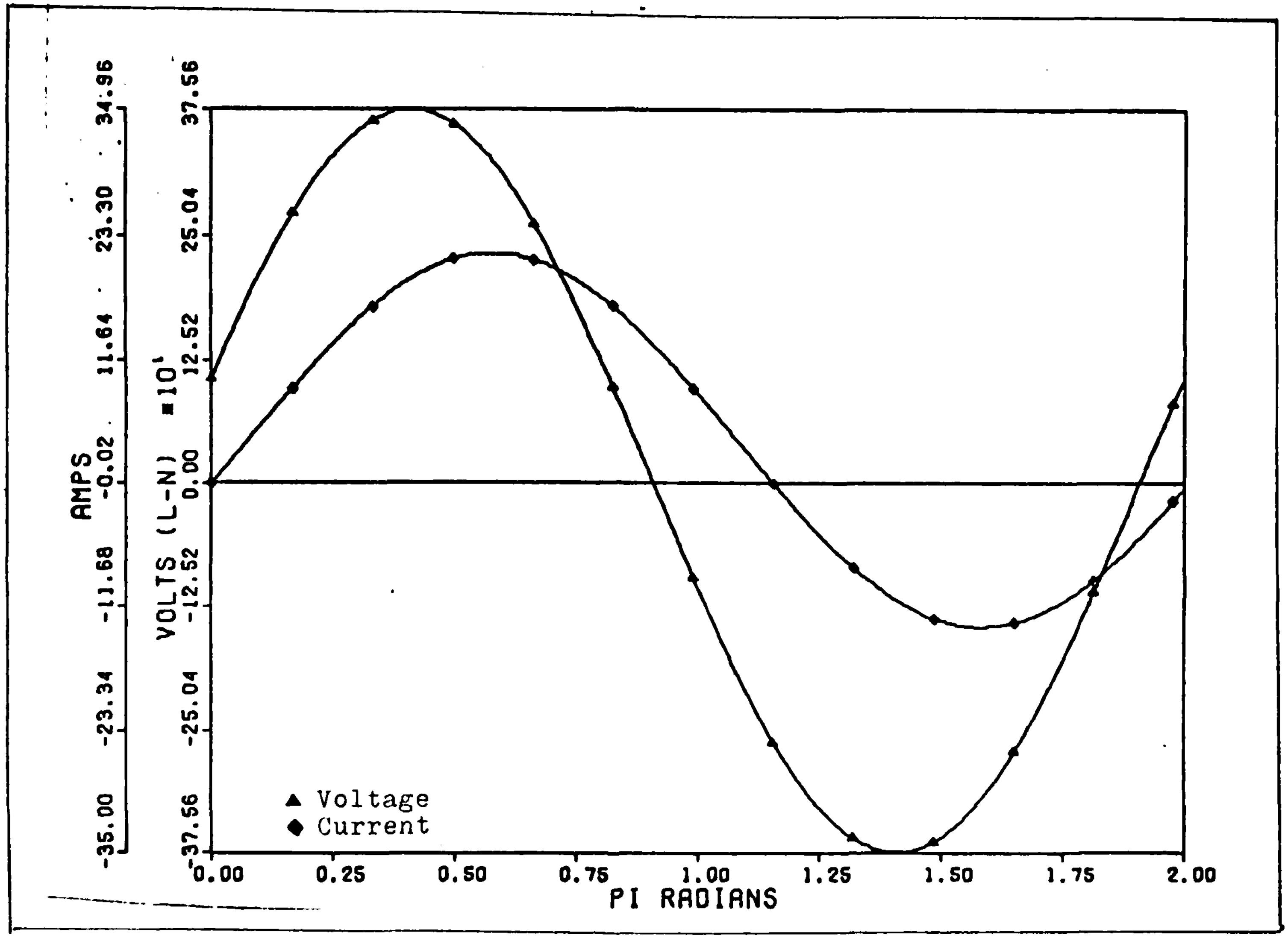


Figure 30

Reflected Voltage and Current Wave for

10 Horse Power Standard with ALPHA equal 0.0

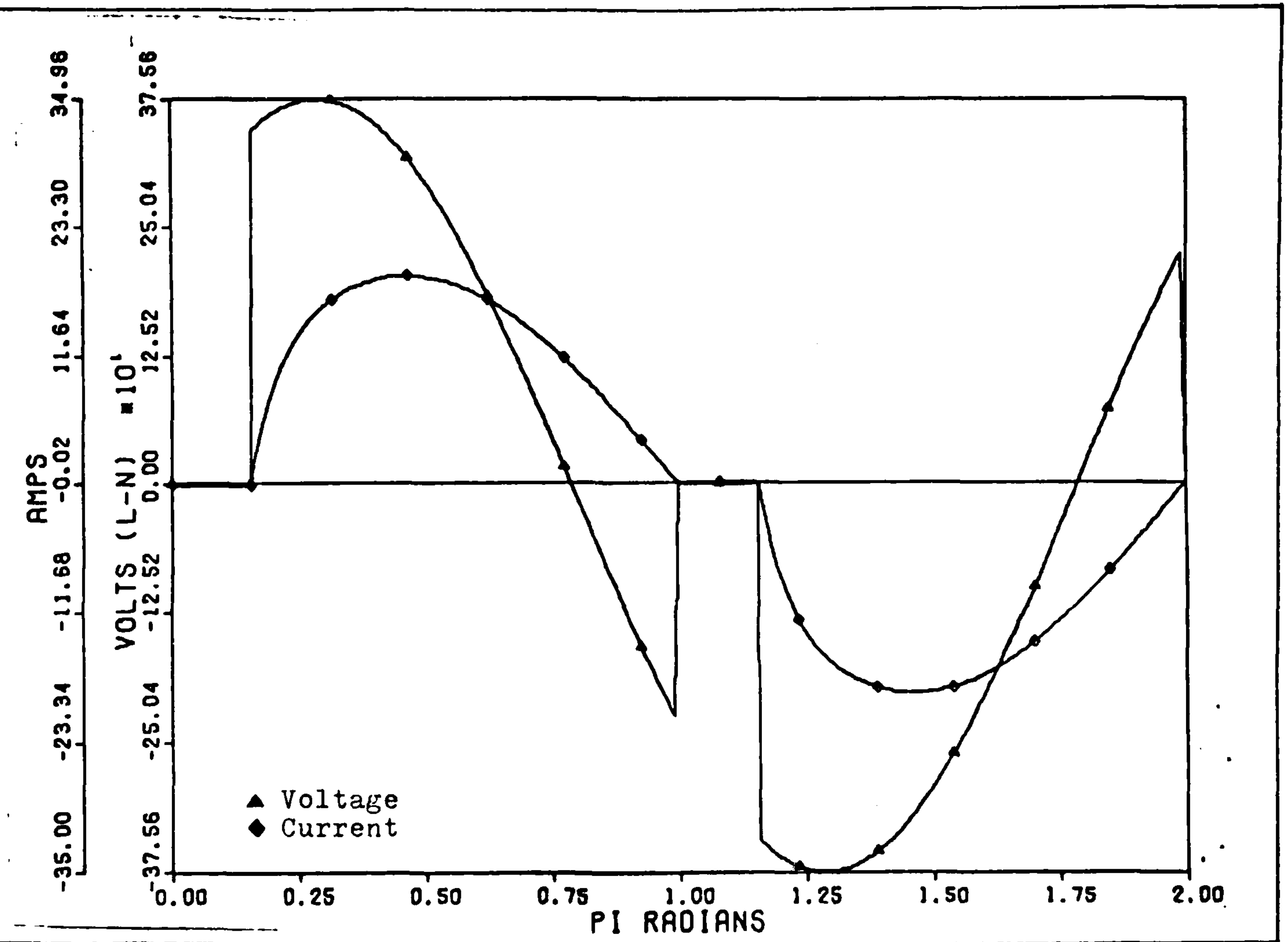


Figure 31

Reflected Voltage and Current Wave for

10 Horse Power Standard with ALPHA equal 0.5

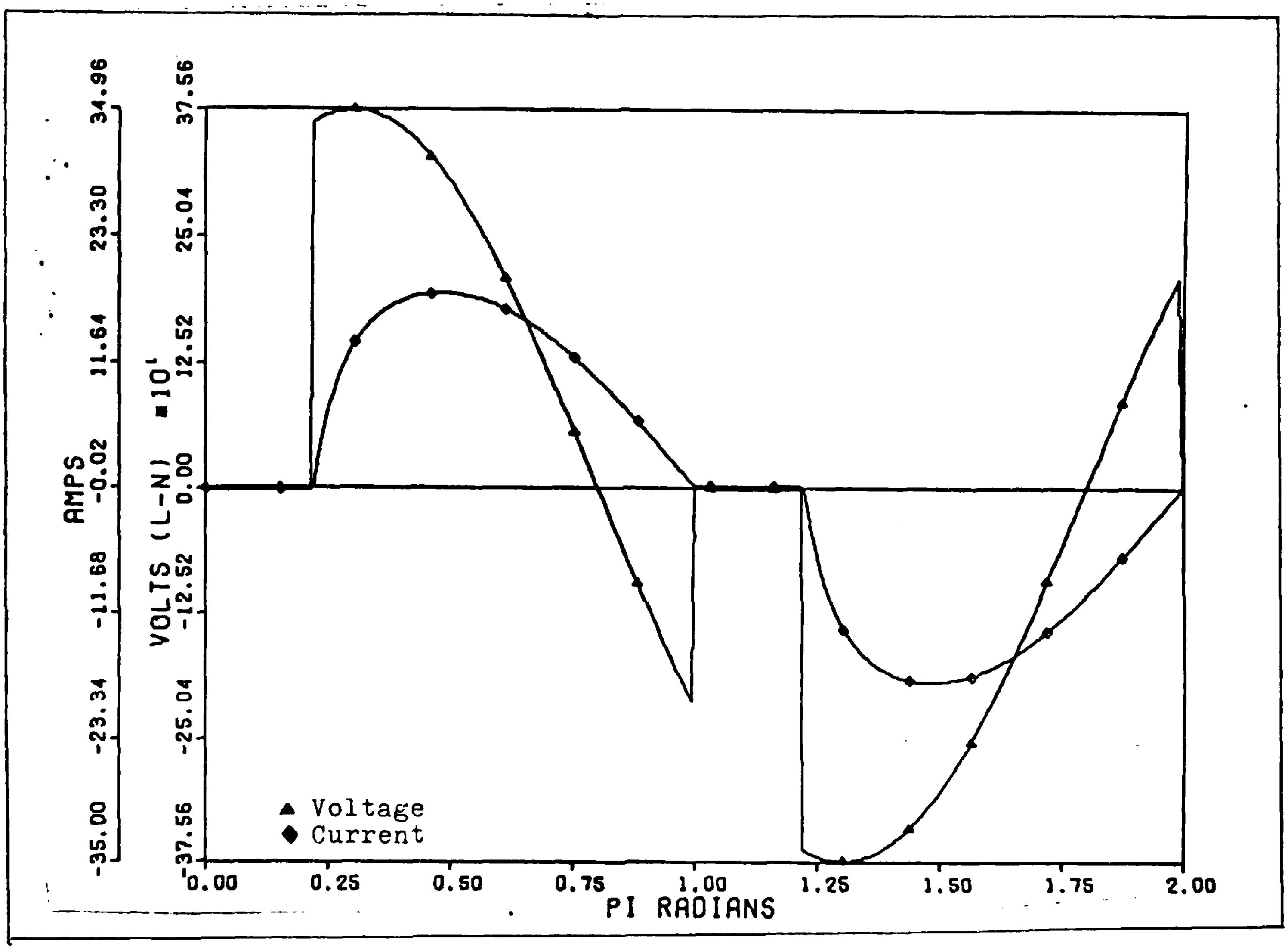


Figure 32

Reflected Voltage and Current Wave for

10 Horse Power Standard with ALPHA equal 0.7

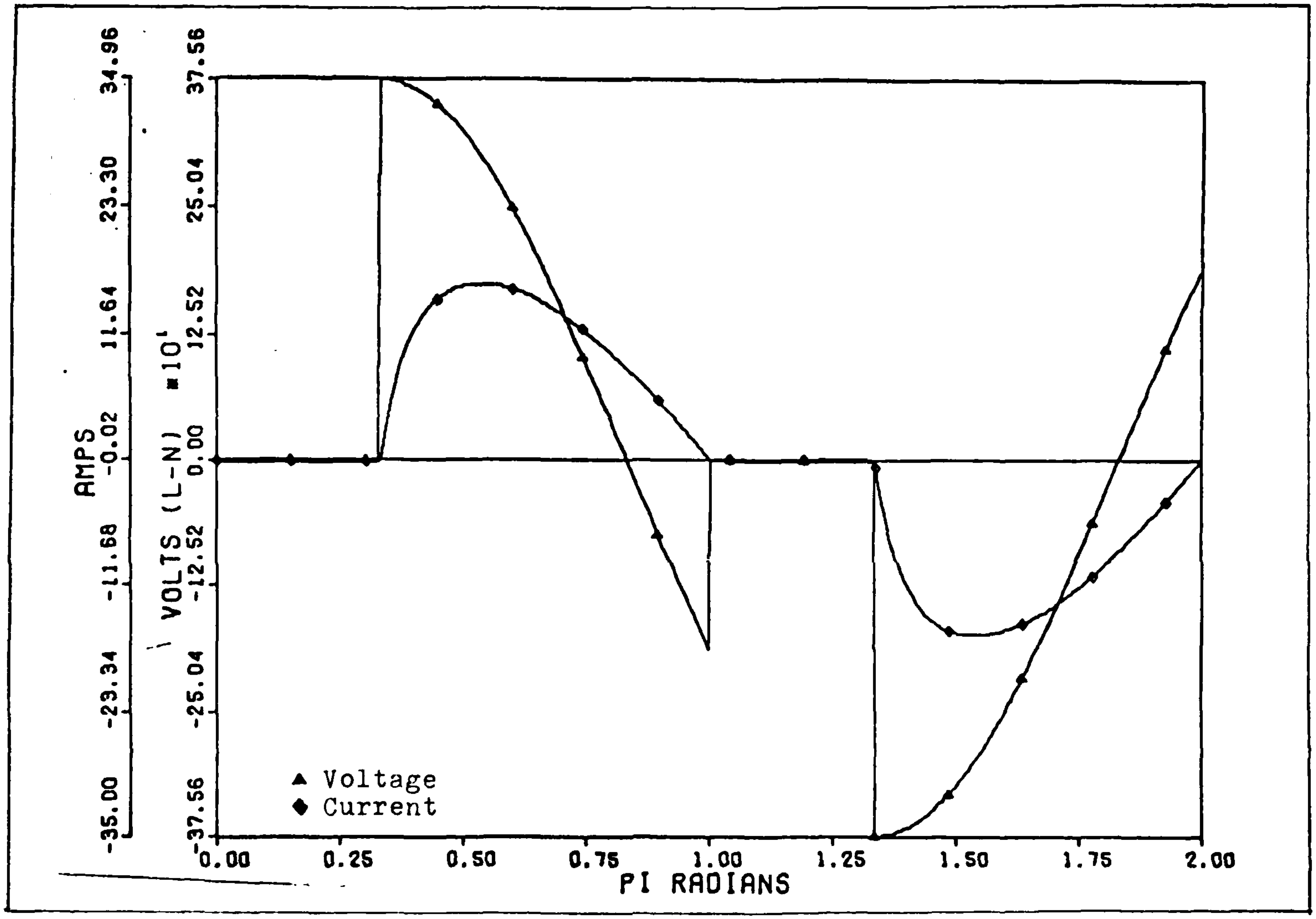


Figure 33

Reflected Voltage and Current Wave for

10 Horse Power Standard with ALFHA equal 1.05

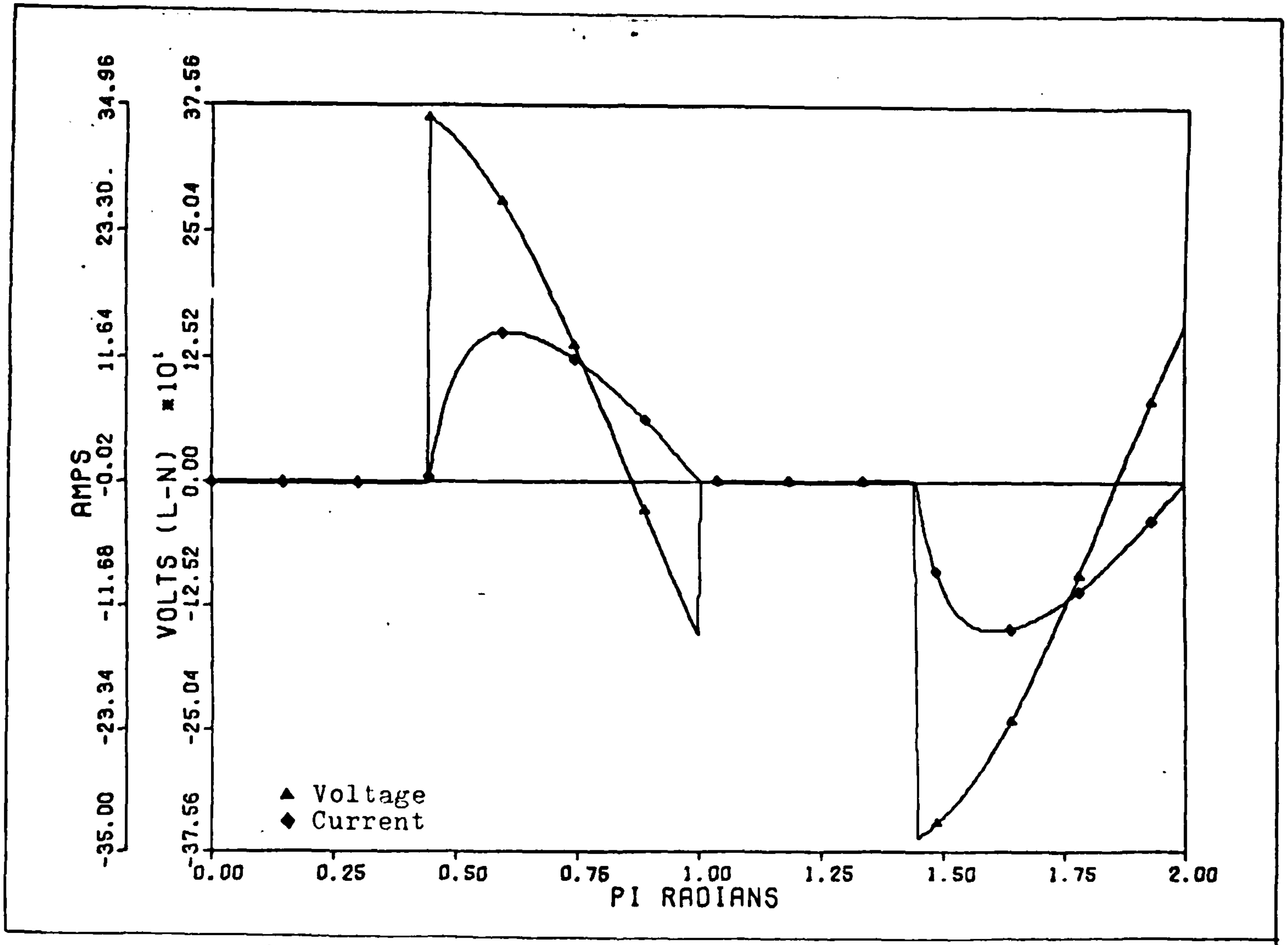


Figure 34

Reflected Voltage and Current Wave for

10 Horse Power Standard with ALFHA equal 1.4

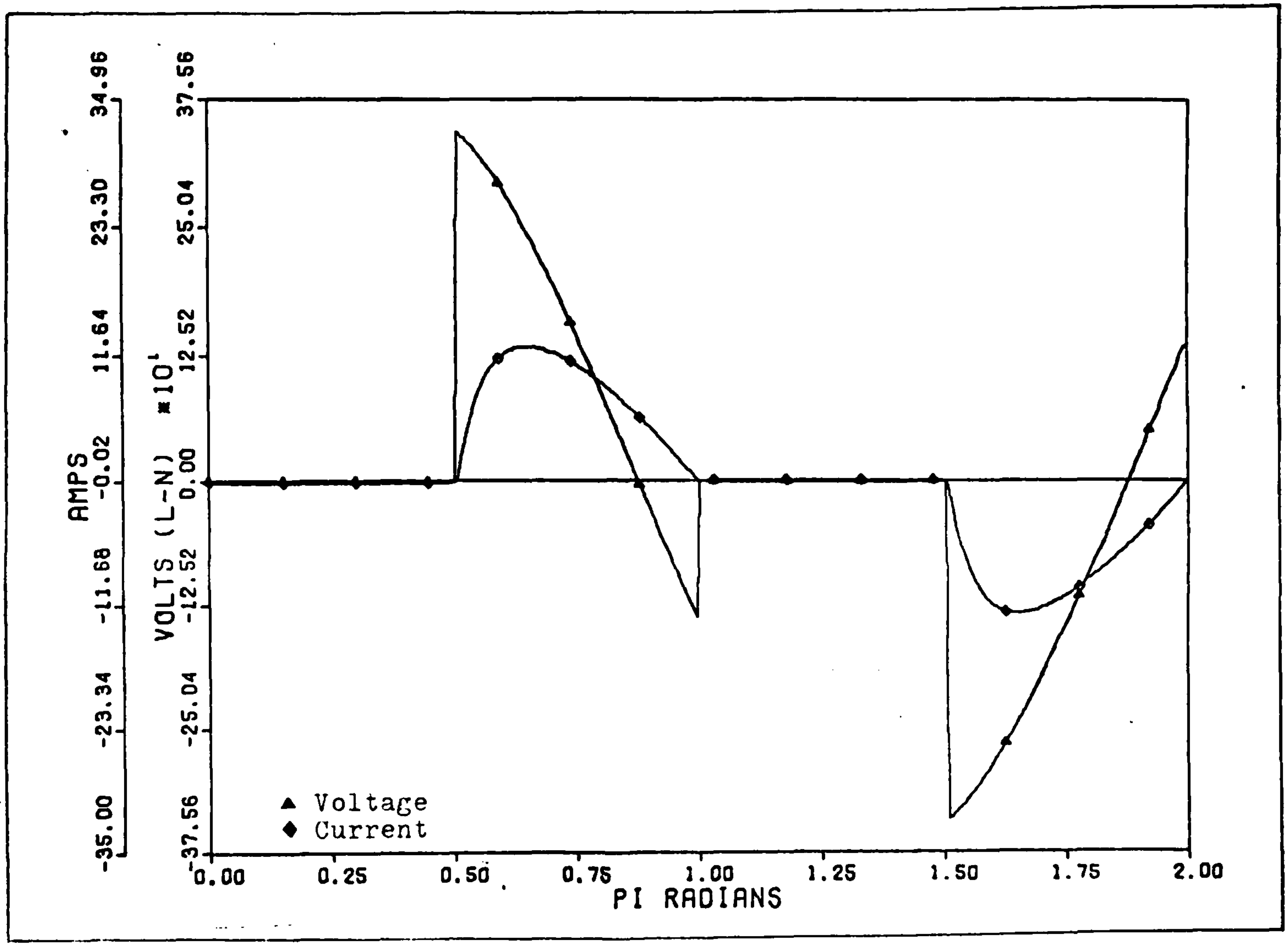


Figure 35

Reflected Voltage and Current Wave for

10 Horse Power Standard with ALFHA equal 1.6

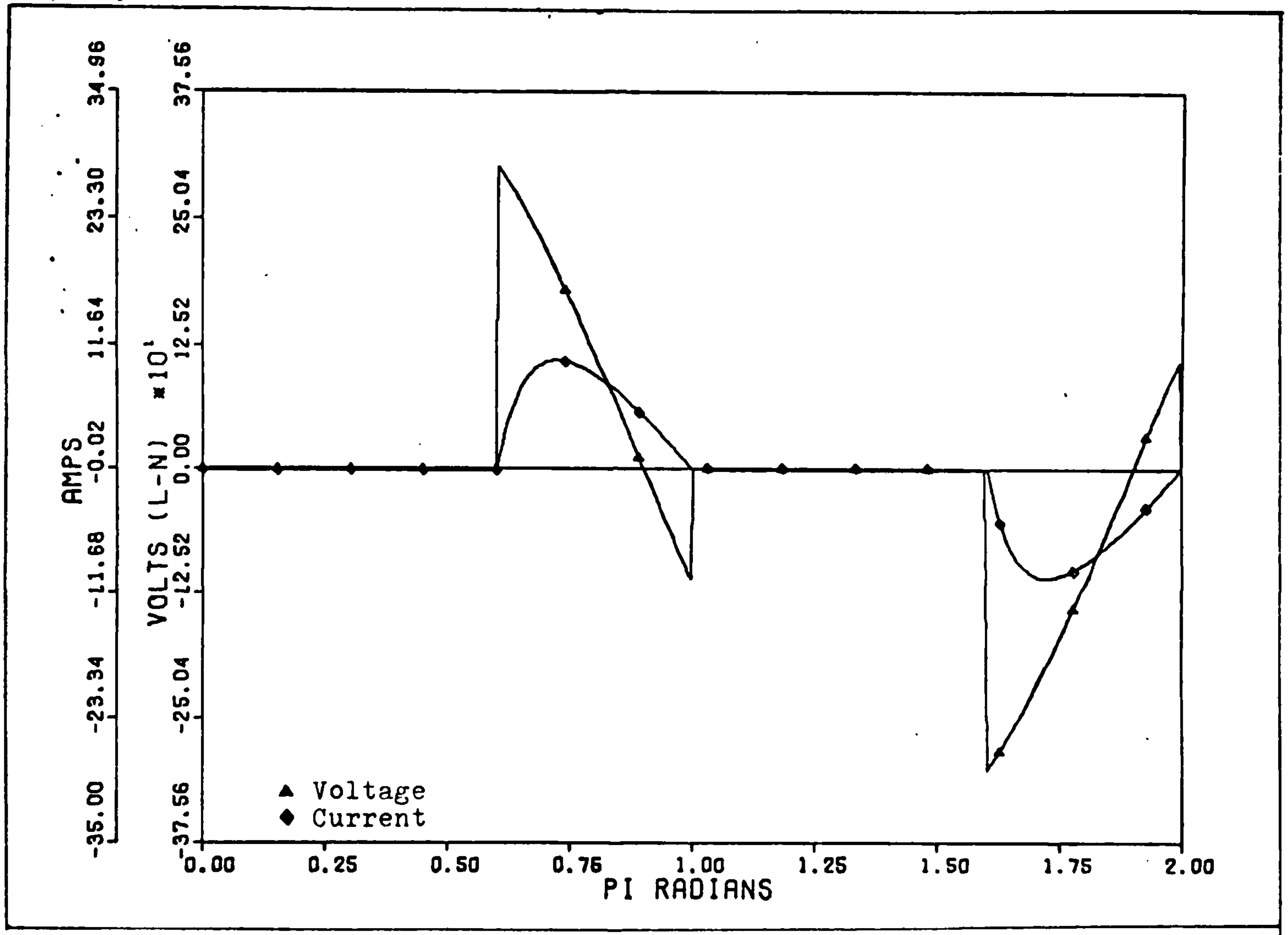


Figure 36

Reflected Voltage and Current Wave for

10 Horse Power Standard with ALPHA equal 1.9

Appendix E

Representation of the

Harmonics Data

From a Fast Fourier Transform

of the Reflected Motor Current

```
TIME , CCS , CVO , CYS , CURT, VITS ,WTS
AVERAGE POWER OUT = 2124.614 665982
HORSE POWER OUTPUT = 2.848 08962443
NF = 337     PNTS = 8008.
 6 ,
B
C
D
E
F
```

	REAL	IMAG	MAG	HARM	PER
1	.7356698E+01	0.	.7355988E+01	0.000	.000
2	-.3551743E+03	.1342561E+04	.1591371E+04	1.000	100.000
3	.1133457E+02	-.1091814E+02	.1573757E+02	2.000	.989
4	.7816810E+03	-.8195241E+01	.7817239E+03	3.000	49.137
5	-.5843554E+01	-.4369813E+01	.7537482E+01	4.000	.466
6	-.1851588E+03	.5397911E+02	.1929665E+03	5.000	12.116
7	.3814694E+01	-.3442479E+01	.5138342E+01	6.000	.323
8	.1925249E+03	-.5927591E+02	.2014435E+03	7.000	12.655
9	-.3377284E+01	-.1059178E+01	.3539478E+01	8.000	.222
10	-.5436932E+02	.5575103E+02	.8515275E+02	9.000	5.351
11	.1915202E+01	-.3012540E+01	.3559789E+01	10.000	.224
12	.5205182E+02	-.5824277E+02	.8513375E+02	11.000	5.346
13	-.1495136E+01	.5923655E+00	.1539207E+01	12.000	.131
14	-.1386876E+02	.5113342E+02	.5298184E+02	13.000	3.328
15	.3773156E+00	-.2954275E+01	.3061789E+01	14.000	.194
16	.1558194E+02	-.4070472E+02	.4358483E+02	15.000	2.738
17	-.1774359E+00	.3721413E+00	.4122774E+00	16.000	.026
18	.1347969E+02	.3098124E+02	.3375334E+02	17.000	2.121
19	-.5593016E+00	-.2478965E+01	.2523575E+01	18.000	.165
20	-.3316039E+01	-.2582369E+02	.2712364E+02	19.000	1.704
21	.4988835E+00	.7298168E+00	.8941347E+00	20.000	.056
22	.1850646E+02	.1565145E+02	.2423751E+02	21.000	1.523
23	-.7926567E+00	-.1388652E+01	.1599355E+01	22.000	.100
24	-.1268816E+02	-.7247318E+01	.1461233E+02	23.000	.918
25	.1056431E+01	-.4475365E+00	.1147317E+01	24.000	.072
26	.1929227E+02	.1429097E+01	.1934513E+02	25.000	1.215
27	-.1297728E+01	-.7504840E+00	.1499105E+01	26.000	.094
28	-.1033125E+02	.1419783E+01	.1042835E+02	27.000	.655
29	.5230886E+00	-.6777433E+00	.9251212E+00	28.000	.056
30	.1115813E+02	-.6652014E+01	.1299142E+02	29.000	.816
31	-.7155428E+00	.2565567E+00	.7503534E+00	30.000	.048
32	-.5285319E+01	.7987558E+01	.9577377E+01	31.000	.602
33	.5742754E+00	-.1099385E+01	.1259389E+01	32.000	.081
34	.5427665E+01	-.7665165E+01	.9403333E+01	33.000	.591
35	-.2067596E+00	-.8011879E-01	.2217389E+00	34.000	.014
36	.1858217E+01	.6843810E+01	.7094221E+01	35.000	.446
37	-.4795555E+00	-.1124252E+01	.1222258E+01	36.000	.077
38	-.1173856E+01	-.7519325E+01	.7530524E+01	37.000	.477
39	.1447608E+00	.4949479E+00	.5155397E+00	38.000	.032
40	.3641197E+01	.4948615E+01	.6368989E+01	39.000	.401
41	-.1766233E+00	-.6786174E+00	.7012251E+00	40.000	.044
42	-.3343219E+01	-.2743863E+01	.4323129E+01	41.000	.272
43	.5732731E+00	-.4039949E+00	.7013270E+00	42.000	.044
44	.5126597E+01	.1136459E+01	.5231100E+01	43.000	.331
45	-.7520441E+00	-.5581241E+00	.9349119E+00	44.000	.059
46	-.3340171E+01	-.3595311E+00	.3352310E+01	45.000	.211
47	.1449138E+00	-.3948177E+00	.4205521E+00	46.000	.026
48	.3999870E+01	-.2098913E+01	.4509270E+01	47.000	.283
49	-.3501593E+00	.2795937E+00	.4799948E+00	48.000	.030
50	-.2362593E+01	.2592596E+01	.3507524E+01	49.000	.220
51	.4986152E+00	-.7276778E+00	.8822833E+00	50.000	.055
52	.2524594E+01	-.2714324E+01	.3707159E+01	51.000	.233
53	-.1747438E+00	-.2416433E+00	.2982055E+00	52.000	.019
54	.4348623E+01	.2428918E+01	.2457338E+01	53.000	.155
55	-.3556697E+00	-.7461598E+00	.9315525E+00	54.000	.056
56	-.2539021E+00	-.3246743E+01	.3257123E+01	55.000	.205
57	-.1487323E-01	.4716984E+00	.4711232E+00	56.000	.030
58	.1307235E+01	.2204932E+01	.2557515E+01	57.000	.161
59	-.1493458E+00	-.3549259E+00	.3345531E+00	58.000	.024
60	-.1299333E+01	-.1352333E+01	.1355532E+01	59.000	.117

65	.1106847E+02	-.2298011E+00	.2557379E+00	64.000	.018
66	.1887452E+01	-.6759053E+00	.2151793E+01	65.000	.131
67	-.7500226E+00	.2517963E+00	.4333377E+00	66.000	.028
68	-.1416714E+01	.1011569E+01	.1743759E+01	67.000	.109
69	.4729691E+00	-.4391326E+00	.5454103E+00	68.000	.041
70	.1501196E+01	-.1030554E+01	.1324522E+01	69.000	.115
71	-.1707219E+00	-.1462228E+00	.2247322E+00	70.000	.014
72	.5634894E-01	.1069605E+01	.1071068E+01	71.000	.067
73	-.2959951E+00	-.5558953E+00	.5235113E+00	72.000	.041
74	.2030135E+00	-.1746655E+01	.1758414E+01	73.000	.110
75	-.3153730E-01	.4206317E+00	.4239436E+00	74.000	.027
76	.3576329E+00	.1150872E+01	.1211343E+01	75.000	.076
77	-.4559230E-01	-.3525652E+00	.3555039E+00	76.000	.022
78	-.4684456E+00	-.9308942E+00	.1041928E+01	77.000	.065
79	.3530778E+00	.6628946E-02	.3537403E+00	78.000	.022
80	.1251467E+01	.7069274E+00	.1439314E+01	79.000	.090
81	-.4189124E+00	-.5160627E+00	.5537543E+00	80.000	.042
82	-.5478317E+00	-.6601497E+00	.9249220E+00	81.000	.058
83	.5167127E-01	-.1055830E-01	.6256955E-01	82.000	.004
84	.1141733E+01	-.2179262E+00	.1054293E+01	83.000	.067
85	-.4259351E+00	.1792983E+00	.4530527E+00	84.000	.029
86	-.1026596E+01	.3146657E+00	.1073797E+01	85.000	.067
87	.5717135E+00	-.1998459E+00	.7007549E+00	86.000	.044
88	.1222555E+01	-.3223233E+00	.1264359E+01	87.000	.079
89	-.4271084E+00	-.2414957E+00	.4905545E+00	88.000	.031
90	-.2795101E+00	.4507300E+00	.5303516E+00	89.000	.033
91	-.7657967E-02	-.3321707E+00	.3325591E+00	90.000	.021
92	.5929428E+00	-.1150317E+01	.1293491E+01	91.000	.082
93	-.3451017E+00	.5350372E+00	.6371579E+00	92.000	.040
94	-.2762755E+00	.8501498E+00	.8939937E+00	93.000	.057
95	.3692748E+00	-.3372225E+00	.4934744E+00	94.000	.031
96	.1446411E+00	-.9521033E+00	.9530575E+00	95.000	.060
97	.5554155E-01	.3921889E+00	.3975105E+00	96.000	.025
98	.5459601E+00	.1104557E+01	.1229035E+01	97.000	.077
99	.5647095E-01	-.8300040E+00	.8392013E+00	98.000	.053
100	-.3182952E-01	-.1520324E+01	.1528515E+01	99.000	.096
101	-.4698258E+00	.6701385E+00	.8244224E+00	100.000	.052
102	.5178126E+00	.5411514E+00	.9212341E+00	101.000	.052
103	.2555194E+00	.3416174E+00	.4255053E+00	102.000	.027
104	-.1146857E+01	-.1201383E+01	.1651325E+01	103.000	.104
105	.1314358E+01	.5383003E+00	.1420319E+01	104.000	.089
106	.1058278E+01	.1053197E+01	.1493043E+01	105.000	.094
107	.5453677E+00	-.1166249E+01	.1352136E+01	106.000	.085
108	-.3279536E+00	-.1167182E+01	.1431110E+01	107.000	.094
109	.4324585E+00	-.6130227E+00	.7502102E+00	108.000	.047
110	.3974597E+00	.4357761E+00	.1083337E+01	109.000	.068
111	-.2934437E+00	-.8770105E+00	.9251302E+00	110.000	.058
112	-.1356593E+01	-.8963840E+00	.1535061E+01	111.000	.095
113	.1329262E+00	-.6892995E+00	.7013335E+00	112.000	.044
114	.1013249E+01	.3982220E+00	.1085694E+01	113.000	.068
115	-.3771834E+00	-.4133435E+00	.9535325E+00	114.000	.061
116	-.1110644E+01	-.3306106E+00	.1150333E+01	115.000	.073
117	.3136701E-01	-.1386345E+00	.1423339E+00	116.000	.009
118	.7250241E+00	.4771479E-01	.7255325E+00	117.000	.046
119	-.2690246E+00	-.1432371E-01	.2893306E+00	118.000	.018
120	-.7635546E+00	.1329029E+00	.7750347E+00	119.000	.049
121	.3411954E-01	-.6042361E+00	.6115225E+00	120.000	.038
122	.4597319E+00	-.2727451E+00	.5345497E+00	121.000	.034
123	-.5398399E+00	-.3160429E-01	.5407555E+00	122.000	.034
124	-.3741752E+00	.3240743E+00	.4950353E+00	123.000	.031
125	-.1596519E+00	-.1616572E+00	.2413333E+00	124.000	.015
126	.2863683E-01	-.4275463E+00	.4255047E+00	125.000	.027

132	.1842237E+00	.1671854E+00	.2497754E+00	131.000	.016
133	-.2237131E+00	-.1411535E+00	.3169335E+00	132.000	.020
134	-.4467192 E+00	-.418 423E-01	.4521868E+00	133.000	.029
135	-.1484132E-01	-.1816338E+00	.1822793E+00	134.000	.011
136	.3027378E+00	.1896592E-01	.3033313E+00	135.000	.019
137	-.1433983E+00	.9011917E-01	.1593119E+00	136.000	.011
138	-.3205925E+00	.2066639E+00	.3783198E+00	137.000	.024
139	-.3909413E-01	-.3334775E+00	.3355393E+00	138.000	.021
140	.1801821E+00	-.3044331E+00	.3537175E+00	139.000	.022
141	-.5226743E-01	.7872332E-01	.9449443E-01	140.000	.006
142	-.1954432E+00	.3647036E+00	.4142420E+00	141.000	.026
143	-.2247295E+00	-.2876539E+00	.3650310E+00	142.000	.023
144	-.7877.6E-01	-.3559183E+00	.3645324E+00	143.000	.023
145	.3233729E-01	.3589293E-01	.8932755E-01	144.000	.006
146	.7496432E-01	.3936318E+00	.4009123E+00	145.000	.025
147	-.3181179E+00	-.1021279E+00	.3245323E+00	146.000	.020
148	-.2849048E+00	-.2821944E+00	.4010114E+00	147.000	.025
149	.2413425E+00	-.1687483E+00	.2933451E+00	148.000	.018
150	.2349403E+00	.1778592E+00	.2945759E+00	149.000	.019
151	-.3825752E+00	-.1662135E-01	.3530539E+00	150.000	.023
152	-.4827135E+00	-.9228836E-02	.4825016E+00	151.000	.030
153	.3217141E-01	-.3025164E+00	.3139635E+00	152.000	.020
154	.3219182E+00	.4776966E-02	.3219436E+00	153.000	.020
155	-.2059835E+00	.2195936E+00	.3010323E+00	154.000	.019
156	-.3850212E+00	.2055022E+00	.4183333E+00	155.000	.026
157	-.4955.6E-01	-.4386461E+00	.4414420E+00	156.000	.028
158	.1552935E+00	-.2769946E+00	.3175589E+00	157.000	.020
159	-.1939176E-01	.2516987E+00	.2514395E+00	158.000	.016
160	-.2229154E+00	.3961294E+00	.4545439E+00	159.000	.029
161	-.2868751E+00	-.4067728E+00	.4977354E+00	160.000	.031
162	-.3537654E-01	-.3211253E+00	.3325377E+00	161.000	.021
163	.1555631E+00	.1741245E+00	.2334349E+00	162.000	.015
164	.5398571E-01	.4267288E+00	.4314933E+00	163.000	.027
165	-.4431846E+00	-.1857353E+00	.4777735E+00	164.000	.030
166	-.2843159E+00	-.2719658E+00	.3927452E+00	165.000	.025
167	.3081917E+00	-.4477216E-01	.3114258E+00	166.000	.020
168	.2221723E+00	.2106332E+00	.3061172E+00	167.000	.019
169	-.4993235E+00	.2187163E-01	.4998123E+00	168.000	.031
170	-.4993235E+00	-.2187163E-01	.4998123E+00	169.000	.031
171	.2221723E+00	-.2106332E+00	.3061172E+00	170.000	.019
172	.3081917E+00	.4477216E-01	.3114258E+00	171.000	.020
173	-.2843159E+00	.2719658E+00	.3927462E+00	172.000	.025
174	-.4431846E+00	.1857353E+00	.4777735E+00	173.000	.030
175	.5398571E-01	-.4267288E+00	.4314933E+00	174.000	.027
176	.1555631E+00	-.1741245E+00	.2334349E+00	175.000	.015
177	-.3537654E-01	.3211253E+00	.3325377E+00	176.000	.021
178	-.2868751E+00	.4067728E+00	.4977354E+00	177.000	.031
179	-.2229154E+00	-.3961294E+00	.4545439E+00	178.000	.029
180	-.1939176E-01	-.2516987E+00	.2514396E+00	179.000	.016
181	.1552935E+00	.2769946E+00	.3175583E+00	180.000	.020
182	-.4955.6E-01	.4386461E+00	.4414420E+00	181.000	.028
183	-.3850212E+00	-.2055022E+00	.4183333E+00	182.000	.026
184	-.2059835E+00	-.2195936E+00	.3010323E+00	183.000	.019
185	.3219182E+00	-.4776966E-02	.3219436E+00	184.000	.020
186	.3217141E-01	.3025164E+00	.3139635E+00	185.000	.020
187	-.4827135E+00	.9228836E-02	.4829016E+00	186.000	.030
188	-.3825752E+00	.1662135E-01	.3530530E+00	187.000	.023
189	.2349403E+00	-.1778592E+00	.2945753E+00	188.000	.019
190	.2413425E+00	.1687458E+00	.2933451E+00	189.000	.018
191	-.2849048E+00	.2821944E+00	.4010 14E+00	190.000	.025
192	-.3181179E+00	.1021273E+00	.3245323E+	191.000	.020

197	-.1964432E+00	-.3647065E+00	.4142421E+00	196.000	.026
198	-.3226743E-01	-.7872302E-01	.3443443E-01	197.000	.016
199	.1800822E+00	.3044331E+00	.3537175E+00	198.000	.122
200	-.3839403E-01	.3334705E+00	.3355333E+00	199.000	.021
201	-.3205925E+00	-.2018539E+00	.3763198E+00	200.000	.024
202	-.1433583E+00	-.9001917E-01	.1593113E+00	201.000	.011
203	.3027378E+00	-.1696542E-01	.3033313E+00	202.000	.019
204	-.1484132E-01	.1816038E+00	.1822033E+00	203.000	.011
205	-.4601920E+00	.4181420E-01	.4620358E+00	204.000	.029
206	-.2837031E+00	.1411535E+00	.3159335E+00	205.000	.020
207	.1842233E+00	-.1671854E+00	.2487754E+00	206.000	.016
208	.1142071E+00	.1170795E+00	.1635569E+00	207.000	.010
209	-.1857054E+00	.3295321E+00	.3787483E+00	208.000	.024
210	-.1801793E+00	.1392917E+00	.2277427E+00	209.000	.014
211	-.4368542E-01	-.4319514E+00	.4381349E+00	210.000	.028
212	-.3705605E-01	-.6606983E-01	.1174130E+00	211.000	.007
213	.2863063E-01	.4275468E+00	.4255147E+00	212.000	.027
214	-.1596519E+00	.1818572E+00	.2419933E+00	213.000	.015
215	-.3741752E+00	-.3240743E+00	.4950053E+00	214.000	.031
216	-.5398399E+00	.3164429E-01	.5407565E+00	215.000	.034
217	.4537319E+00	.2727451E+00	.5345497E+00	216.000	.034
218	.3411954E-01	.6042361E+00	.6115225E+00	217.000	.038
219	-.7635546E+00	-.1329029E+00	.7750347E+00	218.000	.049
220	-.2680246E+00	.1432371E-01	.2893305E+00	219.000	.018
221	.7250241E+00	-.4771479E-01	.7265925E+00	220.000	.046
222	.3136701E-01	.1388345E+00	.1423339E+00	221.000	.009
223	-.1110644E+01	.3360135E+00	.1150533E+01	222.000	.073
224	-.9771634E+00	.4133435E+00	.9595925E+00	223.000	.061
225	.1013249E+01	-.3982220E+00	.1089594E+01	224.000	.068
226	.1329262E+00	.6892995E+00	.7019995E+00	225.000	.044
227	-.1356993E+01	.6983844E+00	.1535051E+01	226.000	.096
228	-.2934497E+00	.8774085E+00	.9251302E+00	227.000	.058
229	.3974534E+00	-.4353751E+00	.1089337E+01	228.000	.068
230	.4324505E+00	.6131227E+00	.7502102E+00	229.000	.047
231	-.3279536E+00	.1167182E+01	.1491110E+01	230.000	.094
232	.5453677E+00	.1180249E+01	.1352196E+01	231.000	.085
233	.1658278E+01	-.1053197E+01	.1493043E+01	232.000	.094
234	.1314358E+01	-.5383003E+00	.1420319E+01	233.000	.089
235	-.1146837E+01	.1201383E+01	.1553325E+01	234.000	.104
236	.2555124E+00	-.3416174E+00	.4255053E+00	235.000	.027
237	.5178028E+00	-.5411504E+00	.8212341E+00	236.000	.052
238	-.4688288E+00	-.6781383E+00	.8244224E+00	237.000	.052
239	-.9182992E-01	.1526324E+01	.1525516E+01	238.000	.095
240	.5847609E-01	.8364040E+00	.8332019E+00	239.000	.053
241	.5459601E+00	-.1045557E+01	.1229306E+01	240.000	.077
242	.5664165E-01	-.3921889E+00	.3978105E+00	241.000	.025
243	.1448411E+00	.9521033E+00	.9530375E+00	242.000	.060

END EFFORT OUT ALL-----------

ALPHA = 1.6

```
   TIME , [illegible] , CYO  , CYS , CURT,  VITS ,WTS
AVERAGE POWER OUT = 1550.932999937
HORSE POWER OUTPUT = 2.0793789554339
  NF =  333      PNTS =  80?0.
    6
A
B
C
D
E
 F
```

	REAL	IMAG	MAG	HARM	PE[illegible]
1	.1497643E+02	0.	.1497643E+02	0.000	1.168
2	-.3128904E+03	.9821781E+03	.1273232E+04	1.000	100.000
3	-.2001864E+01	-.6561043E+01	.6859540E+01	2.000	.539
4	.6853931E+03	.2747393E+03	.7393337E+03	3.000	58.068
5	.5758130E+01	-.2966501E+00	.6754533E+01	4.000	.531
6	-.1091715E+03	-.1705307E+03	.2024856E+03	5.000	15.903
7	-.3530286E+01	-.6735545E+01	.7504724E+01	6.000	.597
8	.1233919E+03	.1330340E+03	.1818570E+03	7.000	14.284
9	.2971609E+01	.2228233E+01	.3713427E+01	8.000	.292
10	-.1239533E+02	-.9061354E+02	.9135342E+02	9.000	7.175
11	-.1871739E+01	-.5742989E+01	.6040309E+01	10.000	.474
12	.3741597E+02	.6593983E+02	.7581557E+02	11.000	5.955
13	.3314274E+00	.2597725E+01	.2728853E+01	12.000	.214
14	.2874948E+01	-.5510445E+02	.5517940E+02	13.000	4.334
15	-.5429826E+00	-.4214263E+01	.4253027E+01	14.000	.335
16	.7722478E+01	.3855651E+02	.3932266E+02	15.000	3.088
17	.2875513E+00	.2315215E+01	.2333034E+01	16.000	.183
18	.5744078E+01	-.3047070E+02	.3100739E+02	17.000	2.435
19	.1435743E+00	-.3488255E+01	.3491209E+01	18.000	.274
20	.1624235E+01	.2691742E+02	.2696540E+02	19.000	2.117
21	-.5693034E-01	.1741774E+01	.1742719E+01	20.000	.137
22	.3642375E+01	-.1914035E+02	.2108193E+02	21.000	1.583
23	.3405359E+00	-.3132303E+01	.3150750E+01	22.000	.247
24	.5015437E+00	.1607951E+02	.1608333E+02	23.000	1.263
25	-.5720165E+00	.1457463E+01	.1503948E+01	24.000	.126
26	.3254295E+01	-.1944441E+02	.1747553E+02	25.000	1.373
27	.6128595E+00	-.2373119E+01	.2417536E+01	26.000	.190
28	-.3339012E+01	.1023893E+02	.1078523E+02	27.000	.847
29	-.7178659E+00	.1378266E+01	.1552237E+01	28.000	.122
30	.5749666E+01	-.9576174E+01	.1115961E+02	29.000	.877
31	.9398401E+00	-.1926169E+01	.2111396E+01	30.000	.166
32	-.3577824E+01	.8952757E+01	.9641137E+01	31.000	.757
33	-.5461227E+00	.9172523E+00	.1121374E+01	32.000	.088
34	.5757654E+01	-.5721994E+01	.8318230E+01	33.000	.632
35	.9873049E+00	-.1883311E+01	.2049049E+01	34.000	.161
36	-.1619254E+01	.5716098E+01	.5929126E+01	35.000	.476
37	-.1009052E+01	.6638219E+00	.1207852E+01	36.000	.095
38	.5133815E+01	-.1657836E+01	.8344745E+01	37.000	.655
39	.5650355E+00	-.1382521E+01	.1534157E+01	38.000	.120
40	-.3061078E+01	.3048449E+01	.4317980E+01	39.000	.339
41	-.9855936E+00	.7413894E+00	.1235708E+01	40.000	.097
42	.3951431E+01	-.3776900E+01	.5490334E+01	41.000	.431
43	.9337808E+00	-.1007657E+01	.1373799E+01	42.000	.108
44	-.3352883E+01	.3230533E+01	.4659433E+01	43.000	.366
45	-.7376601E+00	.4174747E+00	.8441291E+00	44.000	.066
46	.4189394E+01	-.1542983E+01	.4454139E+01	45.000	.351
47	.9148311E+00	-.1056425E+01	.1429365E+01	46.000	.112
48	-.1661490E+01	.2260213E+01	.2310025E+01	47.000	.221
49	-.9615942E+00	.1394780E+00	.9716571E+00	48.000	.076
50	.4250037E+01	-.1943732E+01	.4573903E+01	49.000	.367
51	.5651090E+00	-.6219204E+00	.1057948E+01	50.000	.083
52	-.1962309E+01	.5574521E+00	.2039353E+01	51.000	.160
53	-.1012550E+01	.2073723E+00	.1042358E+01	52.000	.082
54	.2664490E+01	-.1510912E+01	.3063065E+01	53.000	.241
55	.7898244E+00	-.4607866E+00	.9154328E+00	54.000	.072
56	-.2441152E+01	.8462952E+00	.2583595E+01	55.000	.203
57	-.7338556E+00	.1097170E+00	.7420516E+00	56.000	.058
58	.2462532E+01	-.1573581E-01	.2462503E+01	57.000	.193
59	.9496382E+00	-.5498109E+00	.1011058E+01	58.000	.079
60	-.1174313E+01	.8087145E+00	.1424314E+01	59.000	.112

66	.1746374E+01	-.5417949E+00	.1322460E+01	65.000	.143
67	.3339112E+00	-.1102594E+00	.6434298E+00	66.000	.151
68	-.1559826E+01	-.1917569E+00	.1571371E+01	67.000	.123
69	-.7038481E+00	-.1356654E+00	.7157345E+00	68.000	.056
70	.1291657E+01	.4461349E+00	.1365337E+01	69.000	.107
71	.7423866E+00	-.1326974E+00	.7541559E+00	70.000	.059
72	-.7726474E+00	.2151790E+00	.8020511E+00	71.000	.063
73	-.7654165E+00	-.4258866E+00	.8214279E+00	72.000	.065
74	.1751679E+01	.3941682E+00	.1793311E+01	73.000	.141
75	.5176126E+00	-.8902671E-01	.5252129E+00	74.000	.041
76	-.3303817E+00	-.5207631E+00	.6157222E+00	75.000	.048
77	-.9177483E+00	-.4166362E+00	.9171307E+00	76.000	.072
78	.1171810E+01	-.1307463E+00	.1173336E+01	77.000	.093
79	.4554979E+00	.2136582E+00	.5031165E+00	78.000	.040
80	-.3949351E+00	-.1050983E+00	.1080307E+01	79.000	.085
81	-.5169955E+00	-.4350034E+00	.7471224E+00	80.000	.059
82	.3182646E+00	.4817349E+00	.7856597E+00	81.000	.062
83	.5153954E+00	.2534932E+00	.5654154E+00	82.000	.044
84	-.3434427E+00	-.6819647E-01	.5477349E+00	83.000	.043
85	-.5315159E+00	-.7381333E+00	.8354153E+00	84.000	.070
86	.1095731E+01	.7089800E+00	.1300063E+01	85.000	.102
87	.2027821E+00	.3147176E+00	.3743398E+00	86.000	.029
88	.3781652E-01	-.5826381E+00	.5865715E+00	87.000	.046
89	-.5282275E+00	-.6357107E+00	.8235105E+00	88.000	.065
90	.3174801E+00	.9722241E-01	.8232411E+00	89.000	.065
91	.1507522E+00	.5714218E+00	.5909730E+00	90.000	.046
92	-.4545817E+00	-.8633713E+00	.9934734E+00	91.000	.078
93	-.2029181E+00	-.7454337E+00	.7725564E+00	92.000	.061
94	.1787159E+00	.5549449E+00	.5830125E+00	93.000	.046
95	.8887911E-02	.4787898E+00	.4789722E+00	94.000	.036
96	-.3512343E+00	-.3644512E+00	.5207375E+00	95.000	.041
97	-.1244653E+00	-.9848511E+00	.9926549E+00	96.000	.078
98	.5207351E+00	.1145007E+01	.1257858E+01	97.000	.099
99	-.5193422E+00	.4886519E+00	.7981155E+00	98.000	.062
100	.5738126E+01	-.7593401E+00	.1045451E+01	99.000	.082
101	-.5242404E-01	-.5137479E+00	.5175265E+00	100.000	.041
102	.2651920E+00	.4323585E+00	.5184375E+00	101.000	.041
103	-.5318384E+00	.6476823E+00	.9049583E+00	102.000	.071
104	.5306660E+00	-.1253968E+01	.1408391E+01	103.000	.111
105	.3339032E+00	-.4167156E+00	.5339581E+00	104.000	.042
106	-.5191182E+00	.2266719E+00	.6593565E+00	105.000	.052
107	-.1004187E+01	.2916057E+00	.1045236E+01	106.000	.082
108	.7132758E+00	-.1029316E+01	.1253137E+01	107.000	.098
109	.7159343E-01	.3037811E+00	.3121264E+00	108.000	.025
110	-.1743757E+01	-.6657715E-01	.1745301E+01	109.000	.137
111	-.3813152E+00	.7826329E+00	.3749018E+00	110.000	.077
112	.5322669E+00	.7466359E+00	.9197233E+00	111.000	.072
113	.9727184E+00	.4919700E+00	.1090053E+01	112.000	.086
114	-.5606385E+00	-.1169193E-01	.6017552E+00	113.000	.047
115	-.1033115E+00	-.1758963E+00	.2071399E+00	114.000	.016
116	.3876143E+00	.6354225E+00	.1089343E+01	115.000	.086
117	.4600452E+00	.1363380E+00	.4515502E+00	116.000	.036
118	-.4279370E+00	-.7115145E+00	.8252365E+00	117.000	.065
119	-.3530355E+00	-.8725232E-01	.3782393E+00	118.000	.030
120	.3101558E+00	.8712407E+00	.9248014E+00	119.000	.073
121	.4711944E+00	.5337261E+00	.7119575E+00	120.000	.056
122	.1034674E+00	-.6277751E+00	.6352445E+00	121.000	.050
123	.1552195E+00	-.2938193E+00	.3223590E+00	122.000	.025
124	.1095495E+00	.5984272E+00	[illegible]	123.000	.046
125	.2725174E+00	.1182027E+00	.2973552E+00	124.000	.023
126	.2241374E+00	[illegible]	[illegible]	125.000	.047

131	.3391292E-01	-.1915785E-01	.5534513E+00	130.000	.015
132	-.2868177E+00	.4181514E+00	.5374224E+00	131.000	.014
133	.2241669E+00	.9131171E-01	.2415751E+00	132.000	.019
134	.2191131E+00	-.3193585E+00	.3872389E+00	133.000	.031
135	.2130257E-11	-.1553435E+00	.1557377E+00	134.000	.012
136	-.2012075E+00	.4127614E+00	.4591911E+00	135.000	.036
137	.1840781E+00	.1429198E-01	.1945321E+00	136.000	.015
138	.3556987E+00	-.2707241E+00	.4470145E+00	137.000	.035
139	-.1411757E+00	-.1695916E+00	.1374778E+00	138.000	.016
140	-.1655229E+00	.2446676E+00	.2353381E+00	139.000	.023
141	.1486532E+00	.1673056E+00	.1833419E+00	140.000	.014
142	.2971110E+00	-.3181395E+00	.4293478E+00	141.000	.030
143	-.7422565E-01	-.1321878E+00	.1515135E+00	142.000	.012
144	-.2658192E+00	.2143297E+00	.3414553E+00	143.000	.027
145	.2104958E+00	.1204948E+00	.2425437E+00	144.000	.019
146	.2559223E+00	-.2071760E+00	.3370897E+00	145.000	.027
147	-.5296538E-01	-.2259626E+00	.2345727E+00	146.000	.018
148	-.2565131E+00	.2506963E+00	.3585747E+00	147.000	.028
149	.1358886E+00	.1043912E+00	.1713570E+00	148.000	.013
150	.3511901E+00	-.1547067E+00	.3837559E+00	149.000	.030
151	-.1257644E+00	-.2166027E+00	.2521390E+00	150.000	.020
152	-.2234025E+00	.1717412E+00	.2817356E+00	151.000	.022
153	.3641782E-01	.2079767E+00	.2292394E+00	152.000	.018
154	.3579914E+00	-.1744911E+00	.3982520E+00	153.000	.031
155	-.5386990E-01	-.1767134E+00	.1327533E+00	154.000	.014
156	-.2711210E+00	.1066758E+00	.2911510E+00	155.000	.023
157	.1511003E+00	.2172123E+00	.2645415E+00	156.000	.021
158	.3225991E+00	-.1429309E+00	.3529325E+00	157.000	.028
159	.5282142E-12	-.2586985E+00	.2587747E+00	158.000	.020
160	-.3151174E+00	.1189422E+00	.3355173E+00	159.000	.026
161	.7816108E-01	.1553141E+00	.1739720E+00	160.000	.014
162	.3603759E+00	-.6612073E-01	.3664458E+00	161.000	.029
163	-.5029725E-01	-.2598112E+00	.2557154E+00	162.000	.021
164	-.2981311E+00	.6521929E-01	.3037324E+00	163.000	.024
165	.3772453E-12	.2393359E+00	.2335354E+00	164.000	.019
166	.3672993E+00	-.3507056E-01	.3866339E+00	165.000	.031
167	.1358753E-12	-.1864973E+00	.1365129E+00	166.000	.015
168	-.2992527E+00	.1716834E-01	.2997448E+00	167.000	.024
169	.5480732E-01	.2491914E+00	.2574798E+00	168.000	.020
170	.3758311E+00	.3552714E-12	.3763310E+00	169.000	.030
171	.5480732E-01	-.2491914E+00	.2574738E+00	170.000	.020
172	-.2992527E+00	-.1716834E-01	.2997449E+00	171.000	.024
173	.1358753E-12	.1864973E+00	.1865129E+00	172.000	.015
174	.3872993E+00	.3507056E-01	.3886339E+00	173.000	.031
175	.3772453E-12	-.2393359E+00	.2335354E+00	174.000	.019
176	-.2981311E+00	-.6521929E-01	.3037324E+00	175.000	.024
177	-.5029725E-01	.2598112E+00	.2557164E+00	176.000	.021
178	.3603759E+00	.6612073E-01	.3664458E+00	177.000	.029
179	.7816108E-01	-.1553141E+00	.1739720E+00	178.000	.014
180	-.3151174E+00	-.1169422E+00	.3358173E+00	179.000	.026
181	.5282142E-12	.2586985E+00	.2587747E+00	180.000	.020
182	.3225991E+00	.1429309E+00	.3529326E+00	181.000	.028
183	.1511003E+00	-.2172123E+00	.2645415E+00	182.000	.021
184	-.2711210E+00	-.1066758E+00	.2911510E+00	183.000	.023
185	-.5356990E-01	.1767134E+00	.1827533E+00	184.000	.014
186	.3579914E+00	.1744911E+00	.7982527E+00	185.000	.031
187	.3641782E-01	-.2079767E+00	.2292394E+00	186.000	.018
188	-.2234025E+00	-.1717412E+00	.2817365E+00	187.000	.022
189	-.1257644E+00	.2166027E+00	.2521387E+00	188.000	.020
190	.3511901E+00	.1547067E+00	.3837559E+00	189.000	.030
191	.1358886E+00	-.1043912E+00	.1713570E+00	190.000	.013
192	-.2565131E+00	-.2306963E+00	.3585747E+00	191.000	.028

198	.2971111E+00	.3081395E+00	.4250479E+00	197.000	.031
199	.1486592E+00	-.1073066E+00	.1833413E+00	198.000	.014
200	-.1655229E+00	-.2446675E+00	.2953931E+00	199.000	.023
201	-.1111757E+00	.1659906E+00	.1974778E+00	200.000	.016
202	.3596987E+00	.2707241E+00	.4470045E+00	201.000	.035
203	.1840731E+00	-.1429198E-01	.1845321E+00	202.000	.015
204	-.2012075E+00	-.4127614E+00	.4591911E+00	203.000	.136
205	.2130257E-01	.1553035E+00	.1567577E+00	204.000	.012
206	.2131131E+00	.3193585E+00	.3872393E+00	205.000	.030
207	.2241659E+00	-.9031171E-01	.2415734E+00	206.000	.019
208	-.2868677E+00	-.4185504E+00	.5074224E+00	207.000	.040
209	.3991292E-01	.4910785E-01	.6331313E-01	208.000	.005
210	.1535723E+00	.6191267E+00	.5378389E+00	209.000	.050
211	.3856994E-01	-.1768779E+00	.1751758E+00	210.000	.014
212	.1846347E-01	-.3944262E+00	.3945581E+00	211.000	.031
213	-.2457265E-01	.3125743E+00	.3135387E+00	212.000	.025
214	.2241385E+00	.5602920E+00	.6034510E+00	213.000	.047
215	.2735178E+00	-.1162027E+00	.2973562E+00	214.000	.023
216	.1085455E+00	-.5984207E+00	.6081553E+00	215.000	.046
217	.1562195E+00	.2836193E+00	.3233680E+00	216.000	.025
218	.1034674E+00	.6277751E+00	.6362445E+00	217.000	.050
219	.4711944E+00	-.5337261E+00	.7119505E+00	218.000	.056
220	.3101558E+00	-.8712407E+00	.9243014E+00	219.000	.073
221	-.3680385E+00	.8725232E-01	.3782398E+00	220.000	.030
222	-.4239374E+00	.7115145E+00	.8282365E+00	221.000	.065
223	.4406452E+00	-.1363380E+00	.4515502E+00	222.000	.036
224	.3878143E+00	-.6305422E+00	.1093343E+01	223.000	.086
225	-.1693017E+00	.1758963E+00	.2070599E+00	224.000	.016
226	-.5066395E+00	.1189193E-01	.5067562E+00	225.000	.047
227	.3727184E+00	-.4919700E+00	.1030053E+01	226.000	.086
228	.5322569E+00	-.7466359E+00	.9187233E+00	227.000	.072
229	-.5813082E+00	-.7826329E+00	.9749019E+00	228.000	.077
230	-.1743753E+01	.6657716E-01	.1745901E+01	229.000	.137
231	.7159343E-01	-.3037811E+00	.3121254E+00	230.000	.025
232	.7138358E+00	.1029816E+01	.1253030E+01	231.000	.098
233	-.1034097E+01	-.2916057E+00	.1045296E+01	232.000	.082
234	-.5180192E+00	-.2288709E+00	.5585555E+00	233.000	.052
235	.3339032E+00	.4167156E+00	.5339381E+00	234.000	.042
236	.5306640E+00	.1259968E+01	.1405931E+01	235.000	.111
237	-.5312364E+00	-.6470823E+00	.9049599E+00	236.000	.071
238	.2861921E+00	-.4323585E+00	.5154975E+00	237.000	.041
239	-.5242064E-01	.5137479E+00	.5175265E+00	238.000	.041
240	.5738126E+00	.7993401E+00	.1045451E+01	239.000	.082
241	-.5183422E+00	-.4885518E+00	.7551165E+00	240.000	.062
242	.5207361E+00	-.1145087E+01	.1257359E+01	241.000	.099
243	-.1244653E+00	.9848511E+00	.9926549E+00	242.000	.078

END EFFORT OUT AL-----------

ALPHA = 1.9

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   TIME , CYS  , CYO  ,  CYS ,  CURT,  VITS ,WTS
 AVERAGE POWER OUT = 359.675181891
 HORSE POWER OUTPUT =  1.15237960377
   NF  =  333      PNTS = 8000.
      6
A
B
C
D
E
 F
```

1	.4639556E+01	0.	.4539556E+01	0.000	.346
2	-.5412814E+03	.5581615E+03	.8511.72E+03	1.000	10[illegible]
3	.3151832E+01	-.3989883E+01	.3075351E+01	2.000	1.066
4	.3816104E+03	.4731814E+03	.6078195E+03	3.000	71.498
5	.2192874E+01	-.7956671E+01	.8253321E+01	4.000	.371
6	.1950963E+03	-.2031597E+03	.2813559E+03	5.000	33.167
7	-.2059657E+01	-.2802216E+01	.3477739E+01	6.000	.409
8	-.1601869E+03	.2624084E+02	.1735564E+03	7.000	12.183
9	.1213042E+01	-.1161656E+01	.1682168E+01	8.000	.198
10	.3654393E+02	.4229690E+02	.1054.39E+03	9.000	12.399
11	.2065765E+00	-.2852332E+01	.2859375E+01	10.000	.336
12	-.3754436E+01	-.5778235E+02	.5859390E+02	11.000	6.393
13	-.2820228E+00	-.1189256E+01	.1222239E+01	12.000	.144
14	-.3623275E+01	.4488729E+02	.45.3328E+02	13.000	5.297
15	.4683732E+00	-.1628182E+01	.1534114E+01	14.000	.199
16	.3716331E+02	-.1965371E+02	.4215739E+02	15.000	4.947
17	-.1524638E+00	-.1451032E+01	.1459093E+01	16.000	.172
18	-.2052398E+02	-.2059873E+00	.2052501E+02	17.000	2.414
19	.2028895E+00	-.1518270E+01	.1532731E+01	18.000	.180
20	.2482655E+02	.1381299E+02	.2841.49E+02	19.000	3.342
21	-.5341853E+00	-.1558407E+01	.1682457E+01	20.000	.198
22	.1020439E+01	-.1935305E+02	.1937393E+02	21.000	2.286
23	-.1985747E+00	-.8537161E+00	.8755062E+00	22.000	.103
24	-.5882053E+00	.1312991E+02	.1314907E+02	23.000	1.535
25	-.4436180E+00	-.1667574E+01	.1725666E+01	24.000	.203
26	.1547757E+02	-.9466.674E+01	.1314022E+02	25.000	2.134
27	-.1192287E+01	-.6224.95E+00	.1344798E+01	26.000	.158
28	-.3441121E+01	-.3449537E+01	.9118753E+01	27.000	1.073
29	-.1598819E+00	-.5865573E+00	.6083431E+00	28.000	.072
30	.3390710E+01	.3866643E+01	.1015537E+02	29.000	1.195
31	-.1559927E+01	-.9919324E+00	.1491580E+01	30.000	.171
32	-.7851815E+00	-.1039365E+02	.1042327E+02	31.000	1.226
33	-.7848124E+00	.2519901E+00	.8292754E+00	32.000	.097
34	-.2231918E+01	.4826307E+01	.5317577E+01	33.000	.626
35	-.1126765E+00	-.4173402E+00	.4322332E+00	34.000	.051
36	.5246831E+01	-.4619133E+01	.6930395E+01	35.000	.822
37	-.5095445E+00	-.1310044E+00	.8201399E+00	36.000	.096
38	-.3451638E+01	-.8191707E+00	.5512830E+01	37.000	.648
39	.2584331E-01	.2601221E+00	.2514026E+00	38.000	.031
40	.3841352E+01	.2459205E+01	.4551114E+01	39.000	.537
41	-.4097995E-01	-.4066502E+00	.4107397E+00	40.000	.048
42	-.1406390E+01	-.3807775E+01	.4059193E+01	41.000	.477
43	-.1371075E+00	-.3410880E-01	.1412524E+00	42.000	.017
44	-.2547018E+00	.4054709E+01	.4053343E+01	43.000	.478
45	.2070246E+00	-.2845855E+00	.4367557E+00	44.000	.051
46	.3310732E+01	-.2290844E+01	.4025130E+01	45.000	.474
47	-.1387714E+00	-.4560452E+00	.4751131E+00	46.000	.056
48	-.2291302E+01	.7141569E+00	.2399389E+01	47.000	.282
49	.4661265E-01	-.4914203E+00	.4936511E+00	48.000	.058
50	.4030253E+01	.1140129E+01	.4190093E+01	49.000	.493
51	-.3354957E+00	-.7087326E+00	.7845580E+00	50.000	.092
52	-.3554097E+00	-.3073335E+01	.3093324E+01	51.000	.364
53	-.3259224E+00	-.37 7361E+00	.4943293E+00	52.000	.058
54	.5410050E+00	.2080782E+01	.2177570E+01	53.000	.256
55	-.3317787E+00	-.7117425E+00	.8124457E+00	54.000	.096
56	.2615073E+01	-.2810310E+01	.3838308E+01	55.000	.452
57	-.5645526E+00	-.2695588E+00	.9143774E+00	56.000	.106
58	-.1940226E+01	-.6534081E+00	.2059305E+01	57.000	.242
59	-.3780311E+00	-.8329489E-01	.3970999E+00	58.000	.046
60	.2088553E+01	.5035068E-01	.2033515E+01	59.000	.246

65	-.1394674E+00	.7413146E-01	.1579445E+01	64.000	.119
66	.3665111E+00	-.1441242E+01	.1515798E+01	65.000	.190
67	-.5568507E+00	.1232627E+00	.5722583E+00	66.000	.067
68	-.1725737E+01	-.7214073E-01	.1727244E+01	67.000	.203
69	-.5139796E-01	.4767239E+00	.4794865E+00	68.000	.056
70	.7512335E+00	.5896778E+00	.9529104E+00	69.000	.113
71	.5615415E-01	-.6021825E-01	.8233782E-01	70.000	.010
72	-.5513026E+00	-.7867816E+00	.1019762E+01	71.000	.120
73	-.1578937E+00	.1428465E+00	.2129253E+00	72.000	.025
74	.2425449E-01	.1187017E+01	.1137255E+01	73.000	.140
75	.2179611E+00	-.6037812E-03	.2179313E+00	74.000	.026
76	.7447212E+00	-.6546076E+00	.9915395E+00	75.000	.117
77	-.3596972E-01	-.2988597E+00	.3343516E+00	76.000	.036
78	-.5362664E+00	.4702558E+00	.7132476E+00	77.000	.084
79	-.1033705E+00	-.1529021E+00	.1345558E+00	78.000	.022
80	.1436186E+01	.9686499E-01	.1441453E+01	79.000	.170
81	-.1643931E+00	-.3312811E+00	.3599274E+00	80.000	.044
82	-.2834391E+00	-.1651252E+01	.1932554E+01	81.000	.129
83	-.3716593E+00	-.1988530E+00	.4215129E+00	82.000	.050
84	.4076154E+00	.6695469E+00	.7939544E+00	83.000	.092
85	-.3489699E+00	-.1734409E+00	.3895345E+00	84.000	.046
86	.3785931E+00	-.1433611E+01	.1591418E+01	85.000	.198
87	-.5294832E+00	-.5716211E-01	.5325623E+00	86.000	.063
88	-.1122122E+01	-.3329945E+00	.1170438E+01	87.000	.138
89	-.4019450E+00	.1111166E+00	.4170222E+00	88.000	.049
90	.3502198E+00	.1247723E+00	.8592216E+00	89.000	.102
91	-.5016631E+00	.6166174E-01	.5082561E+00	90.000	.060
92	-.5223131E+00	-.1560539E+01	.1564595E+01	91.000	.196
93	-.4418578E+00	.4424802E+00	.6252215E+00	92.000	.074
94	-.3926221E+00	.6593765E+00	.1191579E+01	93.000	.140
95	-.1277244E+00	.3363175E+00	.3615245E+00	94.000	.043
96	.5710732E+00	-.3764565E+00	.7594535E+00	95.000	.091
97	-.2816516E+00	.3697800E+00	.4648278E+00	96.000	.055
98	-.1304735E+01	-.6082344E+00	.1439542E+01	97.000	.169
99	.5497952E-01	.5618137E+00	.5581394E+00	98.000	.067
100	-.2571344E+00	.1198463E+01	.1223791E+01	99.000	.144
101	.2067552E+00	.1165088E+00	.2373226E+00	100.000	.028
102	.3816470E+00	-.2802411E+00	.4734360E+00	101.000	.056
103	-.1231113E+00	.1561159E+00	.2003354E+00	102.000	.024
104	-.5012411E+00	.4679512E+00	.7743295E+00	103.000	.091
105	-.2937605E-01	.3611623E+00	.3812543E+00	104.000	.045
106	.3155516E+00	.6722158E+00	.1033156E+01	105.000	.121
107	.1327305E+00	.5176361E+00	.5247499E+00	106.000	.062
108	.7351575E-03	-.6996168E+00	.6998172E+00	107.000	.082
109	.5209029E+00	.4964723E+00	.7950347E+00	108.000	.094
110	-.2990143E-01	.5176824E+00	.5135452E+00	109.000	.061
111	.3165688E+00	-.1549346E+00	.9295715E+00	110.000	.109
112	.7403877E+00	-.5989516E+00	.9510653E+00	111.000	.112
113	.4657991E+00	-.7677758E+00	.8932129E+00	112.000	.106
114	-.7658855E+00	-.4591013E+00	.8927751E+00	113.000	.105
115	-.2565378E+00	-.6932773E+00	.7392192E+00	114.000	.087
116	.1543824E+00	.4358434E+00	.4523925E+00	115.000	.050
117	-.4042450E+00	-.1364450E+00	.4268521E+00	116.000	.050
118	-.1609106E+00	-.6158493E+00	.5355213E+00	117.000	.075
119	-.1834255E+00	-.3265043E-01	.1983439E+00	118.000	.022
120	-.3855515E+00	.7181762E+00	.9255564E+00	119.000	.109
121	-.2053350E+00	.8417320E-01	.2219035E+00	120.000	.026
122	.3149620E+00	.1522371E+00	.9275405E+00	121.000	.109
123	.1190458E+00	.7377862E-01	.1410342E+00	122.000	.016
124	-.3706773E+00	-.5765330E+00	.5351332E+00	123.000	.081
125	-.1100433E+00	-.2470577E+00	.2704571E+00	124.000	.032
126	.5205629E-01	.7146831E+00	.7173723E+00	125.000	.084

132	.2373410E+00	.9172877E-01	.3303124E+00	131.000	.0[illegible]
133	.9978527E-01	.2627814E+00	.2775958E+00	132.000	.033
134	-.3123321E-01	-.5832722E+00	.3993015E+00	133.000	.069
135	.1244445E+00	-.2676332E+00	.3134393E+00	134.000	.037
136	-.2231892E+00	.6920953E-01	.2403575E+00	135.000	.028
137	-.2428341E+00	.2660489E-01	.2442915E+00	136.000	.029
138	.3145795E-01	-.2578993E+00	.2704583E+00	137.000	.032
139	.1662834E+00	-.4988137E-01	.1736039E+00	138.000	.026
140	-.3148555E+00	-.5402732E-01	.3155589E+00	139.000	.037
141	-.2795313E+00	-.2218408E+00	.3498578E+00	140.000	.041
142	.3522678E-01	-.3894314E-01	.6757537E-01	141.000	.006
143	-.3659898E-01	.1911564E+00	.1993375E+00	142.000	.023
144	-.3322856E+00	-.1155386E+00	.3517335E+00	143.000	.041
145	-.4309187E-01	-.2467326E+00	.2504573E+00	144.000	.029
146	.3757036E-01	.2675524E+00	.2698822E+00	145.000	.032
147	-.3426306E+00	.1827049E+00	.3882993E+00	146.000	.046
148	-.3782966E-01	-.2725916E+00	.2752041E+00	147.000	.032
149	.1920122E+00	.5956358E-01	.2010386E+00	148.000	.024
150	-.2805953E+00	.3185708E+00	.4245243E+00	149.000	.050
151	-.3155641E+00	-.1379521E+00	.3444002E+00	150.000	.041
152	.4036193E+00	.3331060E-02	.4035320E+00	151.000	.047
153	.4396017E-02	.3909773E+00	.3310023E+00	152.000	.046
154	-.2944953E+00	-.2231618E+00	.3594387E+00	153.000	.043
155	.1417198E+00	-.2166449E+00	.2583754E+00	154.000	.030
156	.1415486E+00	.3690097E+00	.3955002E+00	155.000	.047
157	-.2982571E+00	.1574599E+00	.3372597E+00	156.000	.040
158	.2089076E+00	-.4074779E+00	.4579039E+00	157.000	.054
159	.3016639E+00	.1109459E+00	.3209559E+00	158.000	.038
160	-.3247653E+00	.7190947E-01	.3325321E+00	159.000	.039
161	-.1640741E+00	-.2510947E+00	.3004506E+00	160.000	.035
162	.3178859E+00	-.4552316E-02	.3173195E+00	161.000	.037
163	-.3445622E-01	.2399746E+00	.2424356E+00	162.000	.029
164	-.2316417E+00	-.3363905E+00	.4094317E+00	163.000	.048
165	.3659913E-01	-.2247478E+00	.2445575E+00	164.000	.029
166	-.5061959E-01	.1895955E+00	.1990508E+00	165.000	.023
167	-.2764159E+00	.6215022E-01	.2833153E+00	166.000	.033
168	.2443814E-01	-.2627347E+00	.2535566E+00	167.000	.031
169	.1176073E+00	.1621226E-01	.1130091E+00	168.000	.014
170	-.2810354E+00	.8751924E-01	.2943745E+00	169.000	.035
171	-.2810355E+00	-.8760924E-01	.2943745E+00	170.000	.035
172	.1176073E+00	-.1621226E-01	.1190091E+00	171.000	.014
173	.2443814E-01	.2627347E+00	.2535560E+00	172.000	.031
174	-.2764159E+00	-.6215022E-01	.2833158E+00	173.000	.033
175	-.5061959E-01	-.1895955E+00	.1990508E+00	174.000	.023
176	.3659913E-01	.2247478E+00	.2445575E+00	175.000	.029
177	-.2316417E+00	.3363905E+00	.4094317E+00	176.000	.048
178	-.3445622E-01	-.2399745E+00	.2424355E+00	177.000	.029
179	.3178859E+00	.4552316E-02	.3173185E+00	178.000	.037
180	-.1645711E+00	.2510947E+00	.3004505E+00	179.000	.035
181	-.3247653E+00	-.7190947E-01	.3325321E+00	180.000	.039
182	.3016639E+00	-.1109459E+00	.3208553E+00	181.000	.038
183	.2089176E+00	.4074779E+00	.4573039E+00	182.000	.054
184	-.2982571E+00	-.1574599E+00	.3372597E+00	183.000	.040
185	.1415486E+00	-.3690097E+00	.3955002E+00	184.000	.047
186	.1417198E+00	.2166445E+00	.2583754E+00	185.000	.030
187	-.2944953E+00	.2231618E+00	.3594387E+00	186.000	.043
188	.4396017E-02	-.3909775E+00	.3310023E+00	187.000	.046
189	.4036193E+00	-.3331060E-02	.4035320E+00	188.000	.047
190	-.3155641E+00	.1379529E+00	.3444002E+00	189.000	.041
191	-.2805953E+00	-.3185709E+00	.4245245E+00	190.000	.050
192	.1920122E+00	-.5956358E-01	.2010386E+00	191.000	.024

197	-.2322856E+00	.1151386E+00	.3317395E+00		
198	-.3659858E-01	-.1911664E+00	.1933375E+00	197.000	.023
199	.5522677E-01	.3891317E-01	.6757537E-01	198.000	.076
200	-.2735313E+00	.2218478E+00	.3498378E+00	199.000	.041
201	-.3144555E+00	.5412732E-01	.3196686E+00	200.000	.037
202	.1682034E+00	.1988137E-01	.1736133E+00	201.000	.122
203	.3145795E-01	.2577993E+00	.2714583E+00	202.000	.032
204	-.2428341E+00	-.2667489E-01	.2442315E+00	203.000	.129
205	-.2231872E+00	-.8929353E-01	.2413575E+00	204.000	.128
206	.1245445E+00	.2870332E+00	.3134393E+00	205.000	.137
207	-.3123321E-01	.5832722E+00	.5883013E+00	206.000	.169
208	.3978527E-01	-.2627814E+00	.2775358E+00	207.000	.033
209	.3734015E+00	-.5172877E-01	.3943524E+00	208.000	.045
210	-.2523389E+00	.1252766E+00	.2928725E+00	209.000	.033
211	-.3984152E+00	.2256048E+00	.4579459E+00	210.000	.054
212	.1807346E+00	.4443577E-01	.1351176E+00	211.000	.122
213	.5853159E+00	.6747532E+00	.8343121E+00	212.000	.098
214	-.2052541E+00	-.1847066E+00	.2783535E+00	213.000	.133
215	.5205629E-01	-.7146831E+00	.7173723E+00	214.000	.184
216	-.1106433E+00	.2471577E+00	.2724571E+00	215.000	.032
217	-.3707773E+00	.5768591E+00	.6851332E+00	216.000	.081
218	.1194458E+00	-.7377862E-01	.1441542E+00	217.000	.116
219	.9149626E+00	-.1522371E+00	.9275405E+00	218.000	.109
220	-.205335 E+00	-.8413527E-01	.2213035E+00	219.000	.126
221	-.3855515E+00	-.7160782E+00	.9265564E+00	220.000	.109
222	-.1834255E+00	.3285049E-01	.1963433E+00	221.000	.122
223	-.1519036E+00	.6158493E+00	.6355213E+00	222.000	.075
224	-.4142451E+00	.1304951E+00	.4256521E+00	223.000	.050
225	.1543821E+00	-.4358494E+00	.4523325E+00	224.000	.054
226	-.2565378E+00	.6932773E+00	.7392192E+00	225.000	.087
227	-.7656859E+00	.4591013E+00	.8927751E+00	226.000	.105
228	.6575975E+00	.7673779E+00	.6932225E+00	227.000	.106
229	.7403877E+00	.5969516E+00	.9510653E+00	228.000	.112
230	.3165688E+00	.1549346E+00	.9235713E+00	229.000	.109
231	-.2990143E-01	-.5170824E+00	.5135452E+00	230.000	.161
232	.5209629E+00	-.4904725E+00	.7350347E+00	231.000	.094
233	.7351507E-03	.6998168E+00	.5938172E+00	232.000	.082
234	.1327301E+01	-.5175851E+00	.5247499E+00	233.000	.162
235	.9155556E+00	-.4722158E+00	.1030156E+01	234.000	.121
236	-.2597675E-01	-.3841623E+00	.3312643E+00	235.000	.145
237	-.5012401E+00	-.4879512E+00	.7743295E+00	236.000	.091
238	-.1231113E+00	-.1581199E+00	.2133354E+00	237.000	.124
239	.3816470E+00	.2832401E+00	.4734960E+00	238.000	.056
240	.2167552E+00	-.1163083E+00	.2373225E+00	239.000	.128
241	-.2571304E+00	-.1196463E+01	.1223781E+01	240.000	.144
242	.9487952E-01	-.5616137E+00	.5581394E+00	241.000	.067
243	-.1304735E+01	.6082344E+00	.1433542E+01	242.000	.169

END EFFORT OUT ALL----------
ALPHA = 2.15

```
  TIME , ICS , CYO  ,  CYS ,  CUPT,  VITS ,WTS
AVERAGE POWER OUT = 4416.733130ECS
HORSE POWER OUTPUT =. 5.923513579899
  NF  =  311      PNTS =  8300.
      G
A
B
C
D
E
 F
```

1	.3159330E+04	0.	.3159330E+04	0.000	152.189
2	-.3537213E+02	-.2076986E+04	.2077287E+04	1.000	104.000
3	-.3079155E+03	-.1214085E+03	.3305218E+03	2.000	15.916
4	-.3517137E+02	-.3154384E+03	.3259970E+03	3.000	15.742
5	-.2793748E+02	-.1193513E+03	.1225774E+03	4.000	5.901
6	-.3165131E+02	-.1336161E+03	.1432566E+03	5.000	6.897
7	-.1466902E+02	-.1122743E+03	.1132259E+03	6.000	5.451
8	-.2159306E+02	-.7882346E+02	.8175405E+02	7.000	3.936
9	-.2012312E+02	-.8548536E+02	.8752190E+02	8.000	4.228
10	-.3743983E+01	-.6745674E+02	.6815516E+02	9.000	3.281
11	-.1552271E+02	-.5946533E+02	.5145332E+02	10.000	2.359
12	-.1217544E+02	-.6142131E+02	.6261544E+02	11.000	3.014
13	-.7699748E+01	-.4798746E+02	.4955125E+02	12.000	2.340
14	-.1428289E+02	-.4901334E+02	.5105292E+02	13.000	2.458
15	-.5643354E+01	-.4578239E+02	.4524238E+02	14.000	2.226
16	-.3931034E+01	-.3808453E+02	.3935397E+02	15.000	1.895
17	-.1016044E+02	-.4192597E+02	.4313356E+02	16.000	2.077
18	-.5955275E+01	-.3438011E+02	.3489722E+02	17.000	1.680
19	-.1077025E+02	-.3473697E+02	.3636333E+02	18.000	1.751
20	-.5751137E+01	-.3320579E+02	.3385545E+02	19.000	1.631
21	-.3431631E+01	-.2948997E+02	.3055412E+02	20.000	1.471
22	-.3308117E+01	-.3026582E+02	.3135542E+02	21.000	1.511
23	-.5985506E+01	-.2742756E+02	.2830315E+02	22.000	1.363
24	-.7661657E+01	-.2688445E+02	.2795459E+02	23.000	1.346
25	-.7844709E+01	-.2527356E+02	.2645383E+02	24.000	1.274
26	-.5845095E+01	-.2481471E+02	.2573196E+02	25.000	1.239
27	-.7285557E+01	-.2287037E+02	.2400277E+02	26.000	1.155
28	-.7712693E+01	-.2295479E+02	.2421386E+02	27.000	1.166
29	-.5009166E+01	-.2161856E+02	.2252128E+02	28.000	1.089
30	-.3253457E+01	-.2032869E+02	.2134215E+02	29.000	1.056
31	-.5321506E+01	-.2106339E+02	.2199154E+02	30.000	1.059
32	-.5916270E+01	-.1653177E+02	.1978032E+02	31.000	.952
33	-.7548318E+01	-.1938465E+02	.2088254E+02	32.000	1.001
34	-.3876658E+01	-.1817053E+02	.1909703E+02	33.000	.919
35	-.7750552E+01	-.1741181E+02	.1905391E+02	34.000	.917
36	-.5353031E+01	-.1744851E+02	.1855910E+02	35.000	.894
37	-.5399037E+01	-.1625756E+02	.1755193E+02	36.000	.850
38	-.3822559E+01	-.1624825E+02	.1758564E+02	37.000	.847
39	-.5583237E+01	-.1555230E+02	.1588925E+02	38.000	.813
40	-.5752541E+01	-.1543620E+02	.1594853E+02	39.000	.811
41	-.5745317E+01	-.1439244E+02	.1539471E+02	40.000	.765
42	-.5774647E+01	-.1471957E+02	.1524327E+02	41.000	.782
43	-.3356534E+01	-.1362779E+02	.1503735E+02	42.000	.724
44	-.7038212E+01	-.1362557E+02	.1533588E+02	43.000	.739
45	-.5149746E+01	-.1365468E+02	.1497564E+02	44.000	.721
46	-.5948223E+01	-.1236209E+02	.1419034E+02	45.000	.683
47	-.5611966E+01	-.1316561E+02	.1473354E+02	46.000	.709
48	-.5313636E+01	-.1187359E+02	.1344776E+02	47.000	.647
49	-.5958031E+01	-.1206781E+02	.1393015E+02	48.000	.671
50	-.5115325E+01	-.1188479E+02	.1335593E+02	49.000	.643
51	-.5659237E+01	-.1124535E+02	.1317784E+02	50.000	.634
52	-.5445612E+01	-.1132190E+02	.1302320E+02	51.000	.627
53	-.5553932E+01	-.1080037E+02	.1253359E+02	52.000	.608
54	-.5528654E+01	-.1068329E+02	.1252023E+02	53.000	.603
55	-.5441676E+01	-.1030563E+02	.1215328E+02	54.000	.585
56	-.5572436E+01	-.1048953E+02	.1237353E+02	55.000	.595
57	-.5473844E+01	-.9642921E+01	.1159225E+02	56.000	.558
58	-.5699933E+01	-.9977452E+01	.1201326E+02	57.000	.579
59	-.5253296E+01	-.9462086E+01	.1134173E+02	58.000	.546
60	-.5657734E+01	-.9096357E+01	.1127344E+02	59.000	.543

[illegible]	-.55226 6E+01	-.6191368E+01	.1053336E+02	64.000	.337
66	-.5239735E+01	-.8512 8E+01	.1054363E+02	65.000	.398
67	-.5652745E+01	-.7688793E+01	.1032442E+02	66.000	.497
68	-.5312379E+01	-.7944263E+01	.1014579E+02	67.000	.488
69	-.5586005E+01	-.7764347E+01	.1015142E+02	68.000	.495
70	-.5412692E+01	-.7459944E+01	.9937.23E+01	69.000	.474
71	-.5297642E+01	-.7424915E+01	.9728845E+01	70.000	.468
72	-.5687638E+01	-.7442928E+01	.1000508E+02	71.000	.482
73	-.5165842E+01	-.6914687E+01	.9264475E+01	72.000	.446
74	-.5714334E+01	-.7164815E+01	.9915473E+01	73.000	.473
75	-.5331442E+01	-.6758239E+01	.9260721E+01	74.000	.446
76	-.5319831E+01	-.6549851E+01	.9101533E+01	75.000	.438
77	-.5521248E+01	-.6923959E+01	.9584535E+01	76.000	.461
78	-.5226867E+01	-.6672437E+01	.8537564E+01	77.000	.419
79	-.5591211E+01	-.6642815E+01	.9350903E+01	78.000	.458
80	-.5455938E+01	-.6601135E+01	.9314354E+01	79.000	.424
81	-.5272649E+01	-.6001076E+01	.8553033E+01	80.000	.410
82	-.5527568E+01	-.6174162E+01	.8985231E+01	81.000	.433
83	-.5410662E+01	-.5579234E+01	.8490760E+01	82.000	.409
84	-.5327551E+01	-.5959117E+01	.8591899E+01	83.000	.418
85	-.5651211E+01	-.5461918E+01	.8614182E+01	84.000	.415
86	-.5136958E+01	-.5425917E+01	.8236585E+01	85.000	.397
87	-.5451374E+01	-.5532139E+01	.8503992E+01	86.000	.409
88	-.5539277E+01	-.5107527E+01	.8236237E+01	87.000	.399
89	-.5136519E+01	-.5314033E+01	.8117523E+01	88.000	.391
90	-.5797601E+01	-.5031871E+01	.8457373E+01	89.000	.407
91	-.5146126E+01	-.4813309E+01	.7876509E+01	90.000	.376
92	-.5451885E+01	-.5017381E+01	.8173491E+01	91.000	.393
93	-.5583558E+01	-.4654875E+01	.8082947E+01	92.000	.386
94	-.5016758E+01	-.4604562E+01	.7575533E+01	93.000	.365
95	-.5989522E+01	-.4915325E+01	.8539165E+01	94.000	.411
96	-.5808327E+01	-.3806543E+01	.6944523E+01	95.000	.334
97	-.7015154E+01	-.5171312E+01	.8714831E+01	96.000	.420
98	-.5758116E+01	-.3418384E+01	.6722314E+01	97.000	.324
99	-.5980562E+01	-.4951133E+01	.8553151E+01	98.000	.412
100	-.5911435E+01	-.3579188E+01	.6915920E+01	99.000	.333
101	-.5870651E+01	-.4254114E+01	.8031565E+01	100.000	.389
102	-.5081254E+01	-.3815548E+01	.7179219E+01	101.000	.346
103	-.5557477E+01	-.3795370E+01	.7575531E+01	102.000	.365
104	-.5385113E+01	-.3797462E+01	.7423933E+01	103.000	.358
105	-.53183 E+01	-.3664951E+01	.7304302E+01	104.000	.352
106	-.5603874E+01	-.3537839E+01	.7485878E+01	105.000	.360
107	-.5288457E+01	-.34957.8E+01	.7153832E+01	106.000	.345
108	-.5494811E+01	-.3381926E+01	.7322304E+01	107.000	.352
109	-.5377133E+01	-.3311617E+01	.7185509E+01	108.000	.346
110	-.5351241E+01	-.3295359E+01	.7152 54E+01	109.000	.344
111	-.5519569E+01	-.3174572E+01	.7255591E+01	110.000	.350
112	-.5289604E+01	-.3030831E+01	.6935288E+01	111.000	.336
113	-.5564171E+01	-.3032439E+01	.7175345E+01	112.000	.345
114	-.5329846E+01	-.2881463E+01	.6934425E+01	113.000	.335
115	-.5424177E+01	-.2878869E+01	.7039919E+01	114.000	.339
116	-.5474118E+01	-.2813594E+01	.7023192E+01	115.000	.338
117	-.5426352E+01	-.2614359E+01	.6934033E+01	116.000	.334
118	-.5482751E+01	-.2682222E+01	.6914233E+01	117.000	.333
119	-.5468573E+01	-.2481138E+01	.6929159E+01	118.000	.334
120	-.5294813E+01	-.2464951E+01	.6757385E+01	119.000	.326
121	-.5527456E+01	-.2463069E+01	.6975702E+01	120.000	.336
122	-.5359115E+01	-.22201 5E+01	.6735458E+01	121.000	.324
123	-.5435739E+01	-.2322761E+01	.6842072E+01	122.000	.329
124	-.5422681E+01	-.2102227E+01	.675737.E+01	123.000	.325
125	-.5350240E+01	-.2133312E+01	.6538893E+01	124.000	.322
126	-.5448955E+01	-.2062192E+01	.6775752E+01	125.000	.326

131	-.5464618E+01	-.1599193E+01	.6525191E+01	130.000	.319
132	-.5474567E+01	-.1579056E+01	.6564341E+01	131.000	.321
133	-.5330659E+01	-.1616791E+01	.6513254E+01	132.000	.315
134	-.5483781E+01	-.1379418E+01	.6525392E+01	133.000	.319
135	-.5331002E+01	-.1472672E+01	.6513599E+01	134.000	.314
136	-.5414198E+01	-.1326377E+01	.6549302E+01	135.000	.315
137	-.5441572E+01	-.1267019E+01	.6563277E+01	136.000	.316
138	-.5393111E+01	-.1226364E+01	.6599573E+01	137.000	.313
139	-.5431752E+01	-.1112938E+01	.6547640E+01	138.000	.315
140	-.5376111E+01	-.1016553E+01	.6464559E+01	139.000	.311
141	-.5414867E+01	-.1033753E+01	.6497531E+01	140.000	.313
142	-.5414844E+01	-.9425795E+00	.6483721E+01	141.000	.312
143	-.5415717E+01	-.8815919E+00	.6473863E+01	142.000	.312
144	-.5451817E+01	-.8255468E+00	.6504419E+01	143.000	.313
145	-.5356739E+01	-.6931793E+00	.6398398E+01	144.000	.308
146	-.5454183E+01	-.7223397E+00	.6494473E+01	145.000	.313
147	-.5364729E+01	-.6151112E+00	.6394373E+01	146.000	.306
148	-.5448207E+01	-.5399922E+00	.6479778E+01	147.000	.312
149	-.5437556E+01	-.5261063E+00	.6459318E+01	148.000	.311
150	-.5372013E+01	-.3473855E+00	.6351475E+01	149.000	.307
151	-.5452768E+01	-.4053984E+00	.6465489E+01	150.000	.311
152	-.5363598E+01	-.2697119E+00	.6359311E+01	151.000	.307
153	-.5443526E+01	-.2567216E+00	.6449395E+01	152.000	.310
154	-.5428587E+01	-.1595507E+00	.6430485E+01	153.000	.311
155	-.5407657E+01	-.7808361E-01	.6459133E+01	154.000	.308
156	-.5438599E+01	-.3038539E-01	.6438581E+01	155.000	.309
157	-.5408599E+01	.3038539E-01	.6438581E+01	156.000	.309
158	-.5407657E+01	.7808361E-01	.6459133E+01	157.000	.308
159	-.5428587E+01	.1595507E+00	.6430485E+01	158.000	.310
160	-.5443526E+01	.2567216E+00	.6449395E+01	159.000	.310
161	-.5363598E+01	.2697119E+00	.6359311E+01	160.000	.307
162	-.5452768E+01	.4053984E+00	.6465489E+01	161.000	.311
163	-.5372013E+01	.3473855E+00	.6351475E+01	162.000	.307
164	-.5437556E+01	.5261063E+00	.6459318E+01	163.000	.311
165	-.5448207E+01	.5399922E+00	.6479778E+01	164.000	.312
166	-.5354729E+01	.6151112E+00	.6394373E+01	165.000	.306
167	-.5454183E+01	.7223397E+00	.6494473E+01	166.000	.313
168	-.5356739E+01	.6931793E+00	.6398398E+01	167.000	.306
169	-.5451817E+01	.8255468E+00	.6504419E+01	168.000	.313
170	-.5415717E+01	.8815919E+00	.6473863E+01	169.000	.312
171	-.5414844E+01	.9425795E+00	.6483721E+01	170.000	.312
172	-.5414867E+01	.1033753E+01	.6497531E+01	171.000	.317
173	-.5376111E+01	.1016553E+01	.6464559E+01	172.000	.311
174	-.5451752E+01	.1112938E+01	.6547640E+01	173.000	.315
175	-.5393111E+01	.1226364E+01	.6599573E+01	174.000	.313
176	-.5441572E+01	.1267019E+01	.6563277E+01	175.000	.310
177	-.5414198E+01	.1326377E+01	.6549302E+01	176.000	.315
178	-.5351002E+01	.1472672E+01	.6513599E+01	177.000	.314
179	-.5483781E+01	.1379418E+01	.6525392E+01	178.000	.319
180	-.5350659E+01	.1616791E+01	.6512254E+01	179.000	.315
181	-.5474567E+01	.1579056E+01	.6564341E+01	180.000	.321
182	-.5464618E+01	.1599193E+01	.6525191E+01	181.000	.319
183	-.5339548E+01	.1815596E+01	.6511546E+01	182.000	.318
184	-.5456777E+01	.1729125E+01	.6554730E+01	183.000	.322
185	-.5382601E+01	.1987287E+01	.6579183E+01	184.000	.322
186	-.5437155E+01	.1696423E+01	.6784305E+01	185.000	.323
187	-.5440895E+01	.2072182E+01	.6775752E+01	186.000	.326
188	-.5350140E+01	.2133302E+01	.6596899E+01	187.000	.322
189	-.5422681E+01	.2102221E+01	.6757372E+01	188.000	.325
190	-.5435739E+01	.2322761E+01	.6842772E+01	189.000	.329
191	-.5355911E+01	.2229113E+01	.6735466E+01	190.000	.324
192	-.5527456E+01	.2463065E+01	.6976702E+01	191.000	.336

[illegible]	-.5626177E+01	.2076801E+01	[illegible]919E+01	197.000	.3[illegible]9
199	-.5329865E+01	.2886465E+01	.5354425E+01	198.000	.335
200	-.5524171E+01	.3032439E+01	.7175345E+01	199.000	.345
201	-.5289654E+01	.3036931E+01	.6935239E+01	200.000	.336
202	-.5549559E+01	.3147457E+01	.7256591E+01	201.000	.355
203	-.5330241E+01	.3290358E+01	.7152164E+01	202.000	.344
204	-.5377003E+01	.3311617E+01	.7185509E+01	203.000	.346
205	-.5494515E+01	.3381925E+01	.7322394E+01	204.000	.352
206	-.5248457E+01	.3495708E+01	.7159332E+01	205.000	.345
207	-.5530874E+01	.3530839E+01	.7485873E+01	206.000	.356
208	-.5318304E+01	.3664951E+01	.7384302E+01	207.000	.352
209	-.5395112E+01	.3797462E+01	.7428939E+01	208.000	.358
210	-.5557477E+01	.3795370E+01	.7575531E+01	209.000	.365
211	-.5091294E+01	.3815548E+01	.7179219E+01	210.000	.346
212	-.5870651E+01	.4254114E+01	.8391355E+01	211.000	.389
213	-.5911455E+01	.3579188E+01	.6917520E+01	212.000	.333
214	-.5990552E+01	.4951133E+01	.8553151E+01	213.000	.412
215	-.5788106E+01	.3418684E+01	.6722014E+01	214.000	.324
216	-.7615654E+01	.5170812E+01	.8714931E+01	215.000	.420
217	-.5808324E+01	.3506543E+01	.6944523E+01	216.000	.334
218	-.5985522E+01	.4915325E+01	.8533065E+01	217.000	.411
219	-.5016736E+01	.4614562E+01	.7575593E+01	218.000	.365
220	-.5583558E+01	.4654876E+01	.8052347E+01	219.000	.388
221	-.5451865E+01	.5017881E+01	.8177491E+01	220.000	.393
222	-.5146026E+01	.4617309E+01	.7815539E+01	221.000	.376
223	-.5797615E+01	.5031871E+01	.8457373E+01	222.000	.407
224	-.5136519E+01	.5314033E+01	.8117523E+01	223.000	.391
225	-.5539277E+01	.5115527E+01	.8296297E+01	224.000	.399
226	-.5461304E+01	.5532039E+01	.8513392E+01	225.000	.409
227	-.5196558E+01	.5425917E+01	.9235695E+01	226.000	.397
228	-.5651205E+01	.5461918E+01	.8514192E+01	227.000	.415
229	-.5327551E+01	.5959117E+01	.8591599E+01	228.000	.418
230	-.5400402E+01	.5579234E+01	.9430750E+01	229.000	.479
231	-.5527946E+01	.6174162E+01	.8995231E+01	230.000	.433
232	-.5272649E+01	.6004075E+01	.8593033E+01	231.000	.418
233	-.6435938E+01	.6001155E+01	.8914354E+01	232.000	.424
234	-.5581211E+01	.6642815E+01	.9351390E+01	233.000	.450
235	-.5226067E+01	.6072437E+01	.9637554E+01	234.000	.419
236	-.5621248E+01	.6929959E+01	.9584535E+01	235.000	.461
237	-.5319831E+01	.6549851E+01	.9101593E+01	236.000	.438
238	-.5331442E+01	.6758239E+01	.9250721E+01	237.000	.446
239	-.5710334E+01	.7164815E+01	.9315473E+01	238.000	.473
240	-.5165842E+01	.6914687E+01	.9254475E+01	239.000	.446
241	-.5687638E+01	.7442928E+01	.1000508E+02	240.000	.482
242	-.5287642E+01	.7424015E+01	.9728846E+01	241.000	.468
243	-.5412852E+01	.7459904E+01	.9537420E+01	242.000	.474

END FFCRT OUT ALL----------

Appendix F

Calculations and Tables

Showing Cost Comparisons

Calculations For

5 HP Motors

5 HP

#1 Energy Efficient (uncont) VS Standard (uncont)

HP 8760 HR/YR X __ Watts/HR X $.06/KWH X KW/1000 =

Savings/YR

5 8760 HR/YR X 64 W/HR X $.06/KWH X KW/1000 W =

$33.63/YR

4.5 8760 HR/YR X 97 W/HR X $.06/KWH X KW/1000 W =

$50.98/YR

4.0 8760 HR/YR X 129 W/HR X $.06/KWH X KW/1000 W =

$67.80/YR

3.75 8760 HR/YR X 64 W/HR X $.06/KWH X KW/1000 W =

$33.63/YR

3.0 8760 HR/YR X 120 W/HR X $.06/KWH X KW/1000 W =

$63.07/YR

2.5 8760 HR/Yr X 118 W/HR X $.06/KWH X KW/1000 W =

$62.02/YR

2.0 8760 HR/YR X 116 W/HR X $.06/KWH X KW/1000 W =

$60.97/YR

1.25 8760 HR/YR X 113 W/HR X $.06/KWH X KW/1000 W =

$59.39/YR

0.75 8760 HR/YR X 113 W/HR X $.06/KWH X KW/1000 W =

$59.39/YR

5 HP

#2. Energy Efficient (uncont) VS Standard (cont)

HP 8760 HR/YR X ___ Watt/HR X $.06/KWH X KW/1000W = $__/YR

5 8760 HR/YR X 64 Watt/HR X $.06/KWH X KW/1000W = $33.63/YR

4.5 8760 HR/YR X 151 Watt/HR X $.06/KWH X KW/1000W = $79.36/YR

4.0 8760 HR/YR X 108 Watt/HR X $.06/KWH X KW/1000W = $56.76/YR

3.75 8760 HR/YR X 54 Watt/HR X $.06/KWH X KW/1000W = $28.38/YR

3.0 8760 HR/YR X 77 Watt/HR X $.06/KWH X KW/1000W = $ 40.47/YR

2.5 8760 HR/YR X 20 Watt/HR X $.06/KWH X KW/1000W = $ 10.51/YR

2.0 8760 HR/YR X -41 Watt/HR X $.06/KWH X KW/1000W = $-21.54/YR

1.25 8760 HR/YR X -79 Watt/HR X $.06/KWH X KW/1000W = $-41.52/YR

0.75 8760 HR/YR X -130 Watt/HR X $.06/KWH X KW/1000W = $-68.33/YR

5 HP

#3. Energy Efficient (cont) VS Standard (cont)

HP	8760 HR/YR X ____ Watt/HR X $.06/KW X KW/1000 W = $/YR
5	8760 HR/YR X 67 Watt/HR X $.06/KW X KW/1000 W = $35.22/YR
4.5	8760 HR/YR X 110 Watt/HR X $.06/KW X KW/1000 W = $57.82/YR
4.0	8760 HR/YR X 63 Watt/HR X $.06/KW X KW/1000 W = $33.11/YR
3.75	8760 HR/YR X 47 Watt/HR X $.06/KW X KW/1000 W = $24.70/YR
3.0	8760 HR/YR X 46 Watt/HR X $.06/KW X KW/1000 W = $24.18/YR
2.5	8760 HR/YR X 80 Watt/HR X $.06/KW X KW/1000 W = $42.05/YR
2.0	8760 HR/YR X 3 Watt/HR X $.06/KW X KW/1000 W = $ 1.58/YR
1.25	8760 HR/YR X 18 Watt/HR X $.06/KW X KW/1000 W = $ 9.46/YR
0.75	8760 HR/YR X 20 Watt/HR X $.06/KW X KW/1000 W = $10.51/YR

5 HP

#4 Energy Efficient (cont) vs Standard (uncont)

8760 Hr/Yr x ___ Watt/HR x $.06/KWH x KW/1000W=$/YR

HP		
5	67 W/HR	= $35.22/YR
4.5	56 W/HR	= $29.43/YR
4.0	84 W/HR	= $44.15/YR
3.75	57 W/HR	= $29.96/YR
3.0	90 W/HR	= $47.30/YR
2.5	178 W/HR	= $93.55/YR
2.0	161 W/HR	= $84.62/YR
1.25	209 W/HR	=$109.85/YR
0.75	263 W/HR	=$138.23/YR

5 HP

#5 Standard (cont) VS Standard (uncont)

HP 8760 HR/YR X ______ Watts/HR X $.06/KWH X KW/1000 W = $/YR

5 8760 HR/YR X 0 W/HR X $.06/KWH X KW/1000 W = $000.00/YR

4.5 8760 HR/YR X -54 W/HR X $.06/KWH X KW/1000 W = $-28.38/YR

4.0 8760 HR/YR X 21 W/HR X $.06/KWH X KW/1000 W = $ 11.04/YR

3.75 8760 HR/YR X 10 W/HR X $.06/KWH X KW/1000 W = $ 5.26/YR

3.0 8760 HR/YR X 43 W/HR X $.06/KWH X KW/1000 W = $ 22.60/YR

2.5 8760 HR/YR X 98 W/HR X $.06/KWH X KW/1000 W = $ 51.50/YR

2.0 8760 HR/YR X 158 W/HR X $.06/KWH X KW/1000 W = $ 83.05/YR

1.25 8760 HR/YR X 192 W/HR X $.06/KWH X KW/1000 W = $100.92/YR

0.75 8760 HR/YR X 243 W/HR X $.06/KWH X KW/1000 W = $127.72/YR

5 HP

#6 Energy Efficient (cont) VS Energy Efficient (uncont)

HP	
HP	8760 HR/YR X ___ Watt/HR X $.06/KWH X KWH/1000W = $__/YR
5	8760 HR/YR X 3 Watt/HR X $.06/KWH X KWH/1000W = $ 1.58/YR
4.5	8760 HR/YR X -41 Watt/HR X $.06/KWH X KWH/1000W = $-21.55/YR
4.0	8760 HR/YR X -45 Watt/HR X $.06/KWH X KWH/1000W = $-23.65/YR
3.75	8760 HR/YR X -7 Watt/HR X $.06/KWH X KWH/1000W = $ -3.68/YR
3.0	8760 HR/YR X -30 Watt/HR X $.06/KWH X KWH/1000W = $-15.77/YR
2.5	8760 HR/YR X 60 Watt/HR X $.06/KWH X KWH/1000W = $ 31.54/YR
2.0	8760 HR/YR X 45 Watt/HR X $.06/KWH X KWH/1000W = $ 23.65/YR
1.25	8760 HR/YR X 97 Watt/HR X $.06/KWH X KWH/1000W = $ 50.98/YR
0.75	8760 HR/YR X 150 Watt/HR X $.06/KWH X KWH/1000W = $ 78.84/YR

Tables Showing

Cost Comparisons for

5 Horse Power Motor

5 Horse Power Motor and Controller Comparisons

A=New Installation, B=Retrofit

Simple Payback in Years

Load Horse Power	Situation 1A	1B	2A	3A	4A	4B	5A	5B	6A	6B
5.0	1.22	13.22	0	1.16	16.78	28.22	------no savings--------			
4.5	0.88	8.71	0	0.71	20.08	33.78	-19.37	-19.37	-25.2	-25.5
4.0	0.60	6.55	0	1.24	13.39	22.51	49.81	49.81	-23.3	-23.3
3.75	1.22	13.20	0	1.66	19.73	33.18	104.56	104.56	-149.5	-149.5
3.0	0.65	7.04	0	1.70	12.49	21.0	24.33	24.33	-34.9	-34.9
2.5	0.66	7.16	0	0.98	6.32	10.23	10.68	10.68	17.4	17.4
2.0	0.67	7.28	+23.63	25.95	6.98	11.75	6.62	6.62	23.3	23.3
1.25	0.69	7.48	+12.26	4.33	5.38	9.05	5.45	5.45	10.8	10.8
0.75	0.69	7.48	+7.48	3.90	4.28	7.20	4.30	4.30	7.0	7.0

Table N

5 HP Savings/Year Based on $0.06 KWH

HP Load (Situation)	Comparison					
	#1	#2	#3	#4	#5	#6
5	$33.63	$ 33.63	$35.22	$ 35.22	$ 0	$ 1.58
4.5	$50.98	$ 79.36	$57.82	$ 29.43	$-28.38	$-21.55
4.0	$67.80	$ 56.76	$33.11	$ 44.15	$ 11.04	$-23.65
3.75	$33.63	$ 28.38	$24.70	$ 29.96	$ 5.26	$ -3.68
3.0	$63.07	$ 40.47	$24.18	$ 47.30	$ 22.60	$-15.77
2.5	$62.02	$ 10.51	$42.05	$ 93.55	$ 51.50	$ 31.54
2.0	$60.97	$-21.54	$ 1.58	$ 84.62	$ 83.05	$ 23.65
1.25	$59.39	$-41.52	$ 9.46	$109.85	$100.92	$ 50.98
0.75	$59.39	$-68.33	$10.51	$138.23	$127.72	$ 78.84

Table 0

5 HP

Δ Wattage for (Situation)

1. Energy Efficient (uncont) VS Standard (uncont)
2. Energy Efficient (uncont) VS Standard (Cont)
3. Energy Efficient (cont) VS Standard (cont)
4. Energy Efficient (Cont) VS Standard (uncont)
5. Standard (cont) VS Standard (uncont)
6. Energy Efficient (cont) VS Energy Efficient (uncont)

Savings in Watts

HP Load	#1	#2	#3	#4	#5	#6
5	64	64	67	67	0	3
4.5	97	151	110	56	-54	-41
4.0	129	108	63	84	21	-45
3.75	64	54	47	57	10	-7
3.0	120	77	46	90	43	-30
2.5	118	20	80	178	98	60
2.0	116	-41	3	161	158	45
1.25	113	-79	18	209	192	97
0.75	113	-130	20	263	243	150

Table P

#1

5 HP

Simple Payback

Cost/Savings per Year

Standard $329.00, Energy Efficient 370.00

A= Cost = $41.00, B= Cost = $370.00 + 20% = $444.00

Installation Cost

HP Load	A	B
5	1.22 yrs	13.20 yr
4.5	0.80 yrs	8.71 yr
4.0	0.60 yrs	6.55 yr
3.75	1.22 yrs	13.20 yr
3.0	0.65 yrs	7.04 yr
2.5	0.66 yrs	7.16 yr
2.0	0.67 yrs	7.28 yr
1.25	0.69 yrs	7.48 yr
0.75	0.69 yrs	7.48 yr

B= Retrofit - Replacing Standard Motor with Energy Efficient + 20% Motor Cost Installation

A= New Installation, Cost of Energy Efficient vs Standard Motor based on continuous operation

Table Q

Situation #2

5 HP

Simple Payback

Cost/Savings Year

Energy Efficient Motor $370.00 + 20% Installation = $444.00

Power Factor Controller $550.00 Including Installation = $550.00

Standard Motor Cost $329.00

A - New installation consider cost only motor/controller

B - Retrofit standard motor with controller vs Energy Efficient motor

HP Load	A	(B not a valid Comparison)
5	0 yr	3.15 yr
4.5	0 yr	1.33 yr
4.0	0 yr	1.86 yr
3.75	0 yr	3.74 yr
3.0	0 yr	2.62 yr
2.5	0 yr	10.08 yr
2.0	-23.63 yr	-4.92 yr
1.25	-12.26 yr	-2.55 yr
0.75	-7.44 yr	-1.55 yr

A. Cost = Energy Efficient Motor - $370.00 + (standard motor $329.00 + Controller $550.00) Cost = $509.00

B. - Energy Efficient Motor + Installation = =$444 + Controller Cost $550 = +$106 less to install Energy Efficient Motor than a controll

Table R

Situation

#3

5 HP

Simple Payback

Cost/Saving year

Energy Efficient (cont) vs Standard (cont)

Energy Efficient Motor $370.00

Controller $550.00

Standard Motor $329.00

A - New Installation - Consider Motor/Controller Cost only.

Cost = ($370 +$550) - ($329+550) = $41.00

Cost = Cost of Energy Efficient Motor + Controller Minus the Cost of Standard Motor + Controller

HP Load	A
5	1.16 yr
4.5	0.71 yr
4.0	1.24 yr
3.75	1.66 yr
3.0	1.70 yr
2.5	0.98 yr
2.0	25.95 yr
1.25	4.33 yr
0.75	3.90 yr

Table S

Situation

#4

5 HP

Simple Payback

Cost/Savings Year

Energy Efficient (cont) vs Standard (uncont)

A - New Installation - Cost = (Energy Efficient Motor + Controller) - (Standard Motor)

Cost = ($370.00 + $550.00) - ($329.00) = $591.00

B - Retrofit - Cost = Energy Efficient Motor + Installation + Controller

Cost = ($444.00 + $550.00) = $994.00

HP Load	A	B
5	16.78 yr	28.22 yr
4.5	20.08 yr	33.78 yr
4.0	13.39 yr	22.51 yr
3.75	19.73 yr	33.18 yr
3.0	12.49 yr	21.00 yr
2.5	6.32 yr	10.63 yr
2.0	6.98 yr	11.75 yr
1.25	5.38 yr	9.05 yr
0.75	4.28 yr	7.20 yr

Table T

Situation

#5

5 HP

Simple Payback

Cost/Savings Year

Standard (cont) vs Standard (uncont)

A - New Installation - Cost = Cost of Controller

Cost = $550.00

B - Retrofit - Same as New Installation

HP Load	A	B
5	No Savings	No Savings
4.5	-19.37 yr	-19.37 yr
4.0	49.81 yr	49.81 yr
3.75	104.56 yr	104.56 yr
3.0	24.33 yr	24.33 yr
2.5	10.68 yr	10.68 yr
2.0	6.62 yr	6.62 yr
1.25	5.45 yr	5.45 yr
0.75	4.30 yr	4.30 yr

Table U

Situation

#6

5 HP

Simple Payback

Cost/Saving Year

Energy Efficient (cont) vs Energy Efficient (uncont)

A - New Installation - Cost = Cost of Controller

Cost = $550.00

B - Retrofit - Same as New Installation

HP Load	A	B
5	348.10 yr	348.10 yr
4.5	-25.52 yr	-25.52 yr
4.0	-23.25 yr	-23.25 yr
3.75	-149.45 yr	-149.45 yr
3.0	-34.87 yr	-34.87 yr
2.5	17.44 yr	17.44 yr
2.0	23.26 yr	23.26 yr
1.25	10.79 yr	10.79 yr
0.75	6.98 yr	6.98 yr

Table V

Tables Showing

Cost Comparisons for

10 Horse Power Motors

10 Horse Power Motor and Controller Comparisons

A= New Installation, B= Retrofit

Simple Payback in Years

Load Horse Power	Situation									
	1A	1B	2A	3A	4A	4B	5A	5B	6A	6B
10	1.15	5.75	NONE	3.27	20.66	33.72	NONE	NONE	-9.45	-9.45
7.5	2.14	10.60	NONE	1.10	11.50	18.77	-14.85	-14.84	67.40	67.40
5.0	3.20	15.98	NONE	2.19	11.24	18.31	50.56	50.56	21.28	21.28
2.5	4.83	24.10	-10.94	14.49	9.42	15.37	8.84	8.84	11.47	11.47

Table W

10 HP

Saving/Year

Based on $0.06 KWH

Comparison

(Situation)

HP Load	#1	#2	#3	#4	#5	#6
10	$138.75	$138.75	$48.88	$48.88	0	$-89.88
7.5	$74.63	$132.45	$145.06	$87.77	$-57.29	$12.61
5.0	$49.93	$33.11	$73.06	$89.88	$16.81	$39.94
2.5	$33.11	$-63.07	$11.04	$107.22	$96.18	$74.11

Table X

10 HP

Δ Wattage for (Situation)

1. Energy Efficient (uncont) VS Standard (uncont)
2. Energy Efficient (uncont) VS Standard (cont)
3. Energy Efficient (cont) VS Standard (cont)
4. Energy Efficient (cont) VS Standard (uncont)
5. Standard (cont) VS Standard (uncont)
6. Energy Efficient (cont) VS Energy Efficient (uncont)

Savings in Watts

HP	#1	#2	#3	#4	#5	#6
10	264	264	93	93	0	-171
7.5	142	252	276	167	-109	24
5.0	95	63	139	171	32	76
2.5	63	-120	21	204	183	141

Table Y

Situation

#1

10 HP

Simple Payback

Cost/Savings Per Year

Standard $505.00, Energy Efficient $665.00

A = Cost = $160.00, B - Cost = $665.00 + 20% = $798.00

Installation Cost

HP Load	A	B
10	1.15 yr	5.75 yr
7.5	2.14 yr	10.60 yr
5.0	3.20 yr	15.98 yr
2.5	4.83 yr	24.10 yr

A - New installation, cost of Energy Efficient vs Standard Motor based on continuous operation.

B - Retrofit - Replacing Standard Motor with Energy Efficient plus 20% of motor cost for installation.

Table Z

Situation

#2

10 HP

Simple Payback

Cost/Savings Year

Energy Efficient motor $66.00+20% installation=$798.00

Power Factor Controller $850.00 including installation

Standard motor cost $505.00

A- New installation - consider only motor/controller cost

B- Retrofit standard motor with controller vs energy efficient motor

A- Cost = energy efficient motor

(-$665.00+$850.00+$505.00)

= $690.00

B- Cost = energy efficient motor + Installation - $798.00 + Controller $850.00

HP LOAD	A
10	4.97 yr
7.5	5.02 yr
5.0	20.84 yr
2.5	-10.94 yr

Table AA

Situation

#3

10 HP

Simple Payback

Cost/Saving Year

Energy Efficient (cont) vs Standard (cont)

Energy Efficient motor $665.00

Controller $850.00

Standard $505.00

A - New Installation

Cost = ($665.00 + $850.00) - ($505.00 + 850)

= $160.00

HP Load	A
10	3.27 yr
7.5	1.10 yr
5.0	2.19 yr
2.5	14.49 yr

Table BB

Situation

#4

10 HP

Simple Payback

Cost/Saving Year

Energy Efficient (cont) vs Standard (uncont)

A - New Installation - Cost = (Energy Efficient Motor + Controller) - (Standard Motor)

Cost = ($665.00 +$850.00) - ($505) = $1010.00

B - Retrofit - Cost - Energy Efficient Motor + Installation + Controller)

Cost = ($798.00 + $850.00) = $1648.00

HP Load	A	B
10	20.66 yr	33.72 yr
7.5	11.50 yr	18.77 yr
5.0	11.24 yr	18.34 yr
2.5	9.42 yr	15.37 yr

Table CC

Situation

#5

10 HP

Simple Payback

Cost/Savings Year

Standard (cont) vs Standard (uncont)

A - New Installation - Cost = Cost of Controller

Cost = $850.00

B - Retrofit - Same as New Installation

HP Load	A	B
10	No Savings	No Savings
7.5	-14.84 yr	-14.84 yr
5.0	50.56 yr	50.56 yr
2.5	8.84 yr	8.84 yr

Table DD

Situation

#6

10 HP

Simple Payback

Cost/Saving Year

Energy Efficient (cont) vs Energy Efficient (uncont)

A - New Installation - Cost = Cost of Controller

Cost = $850.00

B - Retrofit - Same as New Installation

HP Load	A	B
10	-9.45 yr	-9.45 yr
7.5	67.40 yr	67.40 yr
5.0	21.28 yr	21.28 yr
2.5	11.47 yr	11.47 yr

Table EE

Appendix G

Tables Showing Comparisons of Actual Motor Data and Simulated Data

5 Horse Power Energy Efficient

Comparison of the Manufacturer's Motor Performance

Data Versus the Computer Generated Data

HP	Amps		Watts		Speed (RPM)		Efficiency (Percent)		Power Factor (Percent)	
	*	**	*	**	*	**	*	**	*	*
5.0	12.3	12.2	4288	4278	1751	1748	87.0	88.0	87.4	87.8
4.5	11.3	10.9	3424	3368	1761	1760	87.1	88.0	82.9	84.9
3.75	9.9	9.5	3214	3197	1763	1763	87.0	88.0	81.5	84.1
3.0	8.3	8.0	2586	2547	1771	1771	86.5	88.0	78.0	79.6
2.0	6.4	6.4	1775	1743	1781	1781	84.0	85.0	69.1	68.8
0.75	4.9	4.9	797	784	1792	1793	70.1	70.0	40.9	40.2

* Manufacturer's Data

** Computer Data

Table FF

5 Horse Power Standard

Comparison of the Manufacturer's Motor Performance

Data Versus the Computer Generated Data

HP	Amps		Watts		Speed (RPM)		Efficiency (Percent)		Power Factor (Percent)	
	*	**	*	**	*	**	*	**	*	**
5.0	7.0	6.9	4423	4342	1746	1744	84.3	86.0	78.7	79.0
4.5	6.5	6.4	3983	3882	1753	1750	84.3	86.0	76.6	76.4
3.75	5.8	5.7	3353	3261	1763	1759	83.4	85.0	72.5	71.6
3.0	5.2	5.2	2712	2668	1770	1768	82.5	84.1	65.7	65.1
2.0	4.5	4.5	1870	1870	1780	1779	79.8	80.0	52.1	52.1
0.75	3.9	3.9	874	896	1793	1792	64.0	62.0	27.7	28.4

* Manufacturer's Data

** Computer Generated Data

Table GG

10 Horse Power Energy Efficient

Comparison of the Manufacturer's Motor Performance

Data Versus the Computer Generated Data

HP	AMPS		Watts		SPeed (RPM)		Efficiency (Percent)		Power Factor (Percent)	
	*	**	*	**	*	**	*	**	*	**
10	24.2	23.7	8354	8211	1756	1753	89.3	90.0	86.7	86.8
7.5	19.5	18.4	6275	6155	1770	1766	89.2	91.0	80.7	83.9
5.0	14.7	13.6	4246	4150	1780	1778	87.8	90.0	72.7	76.2
2.5	10.6	9.9	2222	2198	1790	1789	83.9	85.0	52.8	55.6

* Manufacturer's Data

** Computer Generated Data

Table HH

10 Horse Power Standard

Comparison of the Manufacturer's Motor Performance

Data Versus the Computer Generated Data

HP	Amps		Watts		Speed (RPM)		Efficiency (Percent)		Power Factor (Percent)	
	*	**	*	**	*	**	*	**	*	**
10	12.6	12.4	8533	8475	1755	1753	87.4	89.0	85.2	85.7
7.5	9.9	9.7	6427	6298	1771	1766	87.0	89.0	81.3	81.1
5.0	7.7	7.5	4329	4244	1780	1778	86.2	88.0	70.4	71.0
2.5	5.8	5.8	2314	2261	1790	1789	80.6	82.0	50.4	48.8

* Manufacturer's Data

** Computer Data

Table II

VITA

Roy D. McMaster was born on 1 July 1947 in Lampassas, Texas. He graduated from Elgin High School in Elgin, Texas in 1965. He then enlisted in the Air Force and served as an electronic navigational equipment repairman until 1972. He then attended New Mexico State University under the AFIT education and commission program. He received his *commission and Bachelor of Science in Electical Engineering.*

After commissioning he served as Base Electrical Engineer until being directed to the School of Engineering, Air Force Institute of Technology to study for a Masters degree in Electrical Engineering.

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SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION
Unclassified

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION/DOWNGRADING SCHEDULE

3. DISTRIBUTION/AVAILABILITY OF REPORT
Approved for public release, distribution unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
AFIT/GE/EE/84S-10

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
Air Force Institute of Tech

6b. OFFICE SYMBOL *(If applicable)*

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS *(City, State and ZIP Code)*
Wright-Patterson AFB, OH 45433

7b. ADDRESS *(City, State and ZIP Code)*

8a. NAME OF FUNDING/SPONSORING ORGANIZATION

8b. OFFICE SYMBOL *(If applicable)*

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS *(City, State and ZIP Code)*

10. SOURCE OF FUNDING NOS.

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.

11. TITLE *(Include Security Classification)*
COST EFFECTIVENESS OF "NOLA" CONTROLLED MOTORS INCLUDING EFFECT OF HIGHER HARMONICS

12. PERSONAL AUTHOR(S)
McMaster, Roy Dean

13a. TYPE OF REPORT
Thesis

13b. TIME COVERED
FROM ________ TO ________

14. DATE OF REPORT *(Yr., Mo., Day)*
84 Jul 2

15. PAGE COUNT
158

Approved for public release: IAW AFR 190-17.
LYNN E. WOLAVER 8 Aug 84
Dean for Research and Professional Development
Air Force Institute of Technology (ATC)
Wright-Patterson AFB OH 45433

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB. GR.

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
Electric Motors
Motor Controllers
Power Systems
Economic Analysis
Energy Conservation

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

An economic analysis of the "NOLA" Power Factor Motor Controller is accomplished and the effects of the harmonics produced by the controller are studied. The controller is placed in series wtih each leg of various sizes of wye-connected three-phase motors. The energy saved by the controller, the power factor correction, and the reflected harmonics under varying load conditions are studied to determine the economic advantages. Also the data from the controlled motor is compared to an energy efficient motor.

An analog-digital computer program is developed which models an induction motor and the "NOLA" controller. The computer model is used to determine and analyze the reflected wave shape produced by the controller.

The results of the study indicates that the energy efficient motor is the most cost effective alternative at the present time because of the high initial cost of the

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL
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22b. TELEPHONE NUMBER *(Include Area Code)*
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22c. OFFICE SYMBOL
AFIT/ENG

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE.

SECURITY CLASSIFICATION OF THIS PAGE

144

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10-84

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